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The regional assessment report on biodiversity and ecosystem services for Europe and Central Asia

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**Plenary of the Intergovernmental Science-Policy
Platform on Biodiversity and Ecosystem Services
Sixth session**

Medellin, Colombia, 18–24 March 2018

Item 6 (d) of the provisional agenda*

**Regional and subregional assessments of biodiversity and
ecosystem services: regional and subregional assessment
for Europe and Central Asia****Chapters of the regional and subregional assessment of
biodiversity and ecosystem services for Europe and Central
Asia****Note by the secretariat**

1. In paragraph 2 of section III of decision IPBES-3/1, the Plenary of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) approved the undertaking of four regional and subregional assessments of biodiversity and ecosystem services for Africa, the Americas, Asia and the Pacific, and Europe and Central Asia (hereinafter called regional assessments) in accordance with the procedures for the preparation of the Platform's deliverables set out in annex I to decision IPBES-3/3, the generic scoping report for the regional assessments of biodiversity and ecosystem services set out in annex III to decision IPBES-3/1, and the scoping reports for each of the four regional assessments (decision IPBES-3/1, annexes IV–VII).
2. In response to decision IPBES-3/1, a set of six chapters and their executive summaries (IPBES/6/INF/3–6), together with a summary for policymakers (IPBES/6/4–7), were produced for each of the regional assessments by an expert group in accordance with the procedures for the preparation of the Platform's deliverables.
3. The annex to the present note, which is presented without formal editing, sets out the chapters of the regional and subregional assessment of biodiversity and ecosystem services for Europe and Central Asia (deliverable 2 (b)), which, together with the summary for policymakers (IPBES/6/7), forms the regional and subregional assessment of biodiversity and ecosystem services for Europe and Central Asia. At its sixth session, the Plenary will be invited to accept the chapters of the assessment, which will be revised following the sixth session to ensure consistency with the summary for policymakers as approved.

* IPBES/6/1.

Annex

Chapters of the regional assessment report on biodiversity and ecosystem services for Europe and Central Asia of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

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Preface

What is an assessment?

An assessment is a critical evaluation of information, to inform decisions on a complex, public issue (Millennium Ecosystem Assessment, 2005). An assessment does not generate new data, but seeks to create new understanding through summary, sorting and synthesis using different methods to manage complexity. It includes academic and grey literature, as well as insights from indigenous and local knowledge (ILK).

The IPBES Regional Assessment for Europe and Central Asia was conducted by a group of experts with a broad range of knowledge and skills, most of whom were nominated by Governments, and the remainder by organizations. The Assessment is supported by evidence, not based on advocacy, and relates to a particular time period (usually 1950-2050, but earlier or later where appropriate) and to the geographical domain of Europe and Central Asia.

The IPBES context for the Regional Assessment for Europe and Central Asia

Objective 2(b) of the IPBES work programme is to “strengthen the science-policy interface on biodiversity and ecosystem services at and across subregional, regional and global levels by producing “regional/subregional assessments on biodiversity and ecosystem services” for: Africa, the Americas, Asia-Pacific, and Europe and Central Asia (Decision IPBES-3/1: Work programme for the period 2014–2018: Annex IV-VII). The implementation of the Regional Assessment for Europe and Central Asia followed a scoping study that responded to requests by Governments, multilateral environmental agreements and other stakeholders in the formulation of key policy questions. These policy questions included: a) general questions relevant to all IPBES regional assessments and, b) questions specific to the Europe and Central Asia region. The scoping study resulted in a generic scoping report (Decision IPBES-3/1: Work programme for the period 2014–2018, Annex III: Generic scoping report for the regional and subregional assessments of biodiversity and ecosystem services (deliverable 2 (b))) and scoping reports for each of the four regions, which have guided the implementation of the Regional Assessment for Europe and Central Asia according to the timetable outlined in **Figure 1**. The IPBES Plenary approved the summary for policymakers, and accepted the chapters of the Assessment Report, at its sixth session in March 2018 (TBC).

Each of the four regional IPBES assessments share the same generic policy questions and follow the same chapter structure, which maps onto the IPBES conceptual framework. All regional assessments also integrate relevant aspects of the IPBES thematic and methodological assessments (outlined below) and consider trans-regional teleconnections in nature, nature’s contributions to people¹ and good quality of life, and in the underlying drivers. While the Regional Assessment for Europe and Central Asia focuses on the regional scale, it also considers subregional or finer scales where necessary. Many examples of drivers, biodiversity, ecosystem services, and good quality of life concern national to local scales. Moreover, the local scale often offers the best opportunity for the integration of indigenous and local knowledge and other knowledge systems. Thus, the general coarse-scale focus of this assessment is rooted in a synthesis of information across a range of scales from local to the Europe and Central Asia region as a whole. The outcomes of the regional assessments are stand-alone

¹ Nature’s contributions to people encompass the positive contributions, or benefits, and occasionally negative contributions, losses or detriments, that people obtain from nature. The term resonates with the original use of the term ecosystem services in the Millenium Ecosystem Assessment (Millennium Ecosystem Assessment, 2005), and goes further by explicitly embracing concepts associated with other worldviews on human–nature relations and knowledge systems.

products that also inform the IPBES Global Assessment on Biodiversity and Ecosystem Services (deliverable 2c).



Figure 1: The deliverables and time table of the first IPBES work programme 2014-2018

The assessment process

The Regional Assessment for Europe and Central Asia was undertaken by an expert team of 118 individuals comprising two assessment co-chairs, a further 12 coordinating lead authors, 85 lead authors, six fellows and 13 review editors. The experts were selected in 2015 by the co-chairs; representatives of the IPBES Bureau and multidisciplinary expert panel (MEP) from the region; and the IPBES secretariat, from nominations by Governments and organizations, to cover a spectrum of disciplines including indigenous and local knowledge. The selected expert team was supported by numerous contributing authors. The 13 review editors assessed the adequacy of author responses to reviewer comments. The evidence presented in the assessment was derived from the peer-reviewed and publicly available literature or correctly cited and publicly available grey literature, as well as indigenous and local knowledge (Roué and Molnár, 2016).

Implementation of the assessment followed eight procedural steps. A first draft of the report chapters was prepared by the author team (1). This draft was peer reviewed in an open and transparent process by Governments, other stakeholders and all interested experts who responded to an invitation by the IPBES Executive Secretary by registering and submitting review comments (2). This facilitated stakeholder engagement and provided a broad set of comments through which the assessment's legitimacy was enhanced. A second draft of the report chapters and first draft summary for policymakers (SPM) were prepared by the author team under the guidance of the review editors and the multidisciplinary expert panel, considering comments from the review (3). These two documents were reviewed a second time by Governments, and other stakeholders (4), leading to the preparation of the final draft of the report chapters and summary for policymakers by the author team under the guidance of the review editors and the multidisciplinary expert panel (5). The summary for policymakers was then translated into the six official languages of the United Nations, checked for accuracy by the author team, and prepared in formats suitable for indigenous and local knowledge holders (6). The final draft of the report chapters and summary for policymakers were made available to, and reviewed by, Governments who provided written comments (7), culminating in the review and approval of the summary for policymakers, and the acceptance of the report chapters at the 6th session of the IPBES Plenary in Medellín in March 2018 (8).

The relationship between the Regional Assessment for Europe and Central Asia and the other IPBES assessments

Besides the four regional assessments, the IPBES work programme (see **Figure 1**) encompasses completed or ongoing assessments including the Thematic Assessment on Pollinators, Pollination and Food Production; the Methodological Assessment on Scenarios and Models of Biodiversity and Ecosystem Services; the Thematic Assessment on Land Degradation and Restoration; and the Global Assessment on Biodiversity and Ecosystem Services. These assessments report at the regional to global scales, and also provide important case studies at the landscape scale. The summary for policymakers of the Thematic Assessment on Pollinators, Pollination and Food Production, was approved and its chapters accepted at the 4th meeting of the Plenary of IPBES in 2016 (IPBES, 2016). It assessed the role of, and status and trends in, animal pollinators and pollination networks and changes in pollination that underpins food production. The assessment informs policy responses to declines and deficits in pollination and contributes to Aichi Biodiversity Target 14 on safeguarding and restoring ecosystems that provide essential contributions to people. The Thematic Assessment on Land Degradation and Restoration provides information to support decision-makers in reducing the negative environmental, social and economic consequences of land degradation, and in restoring degraded land to enhance nature's contributions to people). The assessment identifies areas of concern and the potential solutions to the challenges posed by land degradation as well as highlighting critical knowledge gaps and priority areas for research and investment (Decision IPBES-3/1, Annex VIII: Scoping for a thematic assessment of land degradation and restoration (deliverable 3 (b) (i))). The IPBES Global Assessment on Biodiversity and Ecosystem Services synthesizes evidence based on biodiversity and nature's contributions to people (IPBES/4/INF/9: Guide on the production and integration of assessments from and across all scales (deliverable 2 (a))) from across the Earth. It is based strongly on the outcomes of the four regional and subregional assessments, but also reports on literature that uses methods applied at the global scale. Where appropriate and necessary, information elaborated during the progress toward these other IPBES assessments also contributed to the Regional Assessment for Europe and Central Asia.

The policy context

Almost all countries in Europe and Central Asia use (agreed-upon) relevant international frameworks to guide national strategy and action. The IPBES assessment of Europe and Central Asia was, hence, and as requested by the scoping document, undertaken in the context of the United Nations 2030 Agenda for Sustainable Development and Strategic Plan for Biodiversity 2011–2020. The assessment examines progress towards the Sustainable Development Goals of the 2030 Agenda and the Aichi Biodiversity Targets of the Strategic Plan. Its time frame covers current and projected trends corresponding with timelines for the 2030 Agenda (2030), and the Strategic Plan (2020) and its 2050 vision. The Strategic Plan for Biodiversity 2011–2020, in particular, exists in the broader context of the United Nations Decade on Biodiversity. In 2010, the Parties to the Convention on Biological Diversity invited the United Nations General Assembly to consider declaring 2011–2020 the United Nations Decade on Biodiversity (CBD, 2010), which the General Assembly did in a resolution in the same year, "with a view to contributing to the implementation of the Strategic Plan for Biodiversity for the period 2011–2020" (United Nations, 2011).

The involvement of different stakeholders

Stakeholders can be considered in two groups, based on how they engaged with the Regional Assessment of Europe and Central Asia (Decision IPBES-3/4: Communications, stakeholder engagement and strategic partnership, Annex II: Stakeholder engagement strategy (deliverable 4 (d))):

1. *Contributors* - scientists, knowledge holders including indigenous and local knowledge holders, practitioners and others;
2. *End users* - regional governments, national Governments and multilateral environmental agreements, subnational and local governments, United Nations agencies, inter-governmental organizations, non-governmental organizations (NGOs), other practitioners within the private sector and the public.

As stakeholder engagement is an important element for the relevance, effectiveness, credibility and overall success of IPBES, stakeholder values, needs and concerns were embedded within the assessment process from the start. The Regional Assessment for Europe and Central Asia has engaged with the broader stakeholder community to better understand and communicate the causes of the loss of nature and nature's contributions to people, including the role of humans and the consequences for human well-being. Involving stakeholders is important in recognising their diverse conceptualisations of values, adding societal aspects when assessing drivers and scenarios and evaluating policy support tools. Although different stakeholders may have different priorities, they all aim to have their knowledge, views and values considered within the IPBES process, including its assessments. Stakeholders can bring complementary perspectives to those of Government, which also helps to identify and prioritize the most relevant knowledge gaps. Different stakeholder organizations can play an important role in the engagement of IPBES with different sectors of society. For these reasons, IPBES provides an opportunity for stakeholders to contribute to informing decision-making.

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1 Chapter 1: Setting the scene

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Executive summary

The IPBES Regional Assessment for Europe and Central Asia critically evaluates and summarizes the available knowledge on the status and trends of nature and its contributions to people. Nature is protected for its diverse values and because it is essential for sustaining human life. To conserve the planet's variety of life - including the human species - and to ensure that people benefit from nature's contributions now and into the future, effective policies and actions are required, based on a broad understanding of what is happening and why. The Regional Assessment for Europe and Central Asia supports decision-making processes by identifying options, opportunities and trade-offs building upon the best available data and information in compiling policy-relevant knowledge (1.1).

Assessing new knowledge is highly relevant and timely. More than 50 previous international and national assessments demonstrate that biodiversity and ecosystems have intrinsic value and are essential for human life. Since the publication of the Millennium Ecosystem Assessment in 2005, there are now four times as many scientific papers on biodiversity and ecosystem services, their drivers and their consequences for people, and on related options for decision-making. To support decision-making it is necessary to synthesize the most recent scientific literature in combination with the grey literature and indigenous and local knowledge (1.1).

The assessment responds to requests from Governments. In requesting this assessment, Governments have recognized the problems arising from the loss of biodiversity and nature's contributions to people and the potential of relevant information for future decision-making. Governments posed a number of policy-relevant key questions that underpin the Regional Assessment for Europe and Central Asia. Questions in common with the other IPBES regional assessments concern the dynamics of, and interplay between, nature's contributions to people, the underlying biodiversity and ecosystems, the drivers of change in biodiversity and ecosystems, their diverse values and relevance for human well-being. Further policy-relevant questions are specific to the Europe and Central Asia region. How can ecosystems be protected through investments, regulations and management regimes for terrestrial, freshwater, coastal and marine systems? What are the effects of production, consumption and economic development on biodiversity and ecosystem services and their contributions to human wellbeing? How can sectoral policies and new policy instruments encourage opportunities arising from the contributions of biodiversity and ecosystem services to human well-being? The assessment seeks to inform policy, public and private decisions, to raise public awareness and to initiate new research (1.1, 1.2).

Answering the region-specific key questions offers important knowledge concerning progress toward the Aichi Biodiversity Targets, the Sustainable Development Goals, and national policies. The questions specific to Europe and Central Asia map directly onto the Aichi Biodiversity Targets and are relevant to the Sustainable Development Goals (SDGs). Goals 14 and 15 address biodiversity and ecosystems explicitly and correspond closely with the Aichi Biodiversity Targets. Beyond Goals 14 and 15, several Sustainable Development Goals address the broader importance of biodiversity and ecosystems for human well-being. The European Union Biodiversity Strategy 2020 aims to halt biodiversity loss in the European Union, restoring ecosystems where possible, and stepping up efforts to avert global biodiversity loss. This underpins the European Union's commitment to the Convention on Biological Diversity and the Aichi Biodiversity Targets by integrating policies on the ecosystem services approach into member States' economies and planning. Non-European Union countries contribute to the implementation of the Aichi Biodiversity Targets through national strategies, plans or programmes. Most Europe and Central Asia countries have developed a national biodiversity strategy and a corresponding action plan (1.2, 1.4).

The Regional Assessment for Europe and Central Asia also takes account of the requests and knowledge of actors other than Governments and provides information for them. Identifying the existing and potential links between nature, nature's contributions to people, and human well-being supports the actions of a wide range of stakeholders in addition to Governments. Non-governmental organizations (NGOs), academic organizations and private businesses can protect and enhance biodiversity and ecosystem services through a number of actions, including management practices, education and awareness raising. The assessment provides relevant evidence upon which stakeholders can base such actions, which involved consulting stakeholders throughout the assessment process (1.2, 1.4).

Europe and Central Asia is characterised by strong differences in terms of industrialization and governance that have a high impact on the state of biodiversity and nature's contributions to people. There is large variability between the Europe and Central Asia subregions in governance systems, cultures, economies, ecoregions and sectors, as well as data monitoring and availability. Europe and Central Asia also has a long history of land management with major human intervention arising from high population densities in the west, but less intervention in the east. Europe and Central Asia faces many important transboundary issues, for example for water resources, pollution, and invasive species, which cut across the subregional divisions (1.3).

Processes within Europe and Central Asia have a large influence on the rest of the world, and Europe and Central Asia depends strongly on other world regions. Such influences include teleconnections via global markets that can displace impacts on biodiversity and ecosystems from Europe and Central Asia to other parts of the world, leading to a large ecological footprint elsewhere. Dependencies include the import of food, feed, fibre and other goods. Western and Central Europe's consumption, in particular, has impacts on land, water and biodiversity in other regions of the world (1.3).

The Regional Assessment for Europe and Central Asia addresses the interactions between nature and people through the IPBES conceptual framework, accounting for the different worldviews and values that exist within the region. To guide the assessment process, IPBES has developed and applied a conceptual framework, an integrated valuation approach and a strategy that integrates information from different knowledge systems, including indigenous and local knowledge. A number of actions were implemented to base the assessment on multiple worldviews and value systems, including the knowledge of local practitioners such as farmers and foresters. Thus, the assessment accounts for different worldviews and values, which underpins its credibility, legitimacy and relevance (1.1, 1.5).

The Regional Assessment for Europe and Central Asia communicates confidence in its findings using qualitative self-assessment in line with the standardised IPBES confidence terms. The need for confidence language arises from the differences in the availability of evidence across subregions, across taxa, and over time. Confidence levels for key messages and findings as well as knowledge gaps are used systematically, including a traceable account of their supporting information and data, to facilitate comparison and interpretation towards policy. Data-related and method-related limitations and issues beyond the scope of this assessment are clearly stated (1.5, 1.6).

The evidence base contains inevitable biases in coverage of the different components and values of nature. Only a small proportion of species are studied to any degree. Out of about 8 million species that exist globally, the 2016 Red List of Threatened Species assessed 82,954 of the estimated 1.64 million species that have been described. Within Europe and Central Asia, only 2,493 species were described on the Red List in 2016. Of the studied species some groups have complete coverage (all known bird and mammal species), while other groups have far less known about them (e.g. only 7% of known plants and <1% of fungi). Answering the policy-relevant questions requires knowledge about the three dimensions of values of nature: nature's values (i.e. biodiversity), nature's contributions to people (i.e. ecosystem services) and aspects of good quality of life. While the assessment covers these

276 three dimensions equally, better supporting evidence on nature's contributions to people and good
277 quality of life would improve the assessment's capacity to answer the policy-relevant questions (1.1,
278 1.6).

1.1 Introduction

1.1.1 The purpose of the Regional Assessment for Europe and Central Asia

The conservation and sustainable use of nature matter for its intrinsic value (Batavia & Nelson, 2017) and because it provides the basis for livelihoods, economies and the good quality of life of people throughout the world (Decision IPBES-5/1, Annex IV: Scoping report for a thematic assessment on the sustainable use of wild species: deliverable 3 (b) (iii)). Effective and urgent action is required to halt the loss of biodiversity to secure the planet's variety of life, which includes human life (CBD, 2010b; Tittensor et al., 2014; United Nations, 2015). These actions require a strong knowledge base, good communication between scientists and decision-makers, and the will to act.

The IPBES Regional Assessment for Europe and Central Asia is based on a request from Governments, multilateral environmental agreements and other stakeholders to investigate the key policy questions outlined in **Box 1.1** IPBES member States have recognized the dependence of quality of life and the economy on nature, and have requested new knowledge about the importance of nature for the human species. Hence, the assessment critically evaluates and summarizes the available knowledge on the status and trends of nature (including biodiversity) and nature's contributions to people² (including ecosystem services) and how they support good quality of life. The assessment also evaluates the underlying causes and consequences of change in the past, present and future in support of governance towards sustainability and good quality of life. Section 1.7.2. describes how the policy-relevant questions structure the Regional Assessment for Europe and Central Asia.

Box 1.1: Policy-relevant question

General questions

1. How do biodiversity and ecosystem functions and services contribute to the economy, livelihoods, food security, and good quality of life in the regions, and what are the interdependences among them?
2. What are the status, trends and potential future dynamics of biodiversity, ecosystem functions and ecosystem services that affect their contribution to the economy, livelihoods and well-being in the regions?
3. What are the pressures driving the change in the status and trends of biodiversity, ecosystem functions, ecosystem services and good quality of life in the regions?
4. What are the actual and potential impacts of various policies and interventions on the contribution of biodiversity, ecosystem functions and ecosystem services to the sustainability of the economy, livelihoods, food security and good quality of life in the regions?
5. What gaps in knowledge need to be addressed in order to better understand and assess drivers, impacts and responses of biodiversity, ecosystem functions and services at the regional level?

Questions specific to Europe and Central Asia

6. How can ecosystems that provide ecosystem services, such as those underpinning ecosystem-based adaptation to climate change and nature-based solutions to sustainable development, be protected through investments, regulations and management regimes for terrestrial, freshwater, coastal and marine systems?
7. What are the effects of production, consumption and economic development on biodiversity and ecosystem services and their contribution to human wellbeing? Major links with other regions will be assessed;

² Nature's contributions to people encompass the positive contributions, or benefits, and occasionally negative contributions, losses or detriments, that people obtain from nature. The term resonates with the original use of the term ecosystem services in the Millenium Ecosystem Assessment (Millennium Ecosystem Assessment, 2005), and goes further by explicitly embracing concepts associated with other worldviews on human–nature relations and knowledge systems.

8. How can sectoral policies and new policy instruments encourage opportunities arising from the contribution of biodiversity and ecosystem services to human well-being?

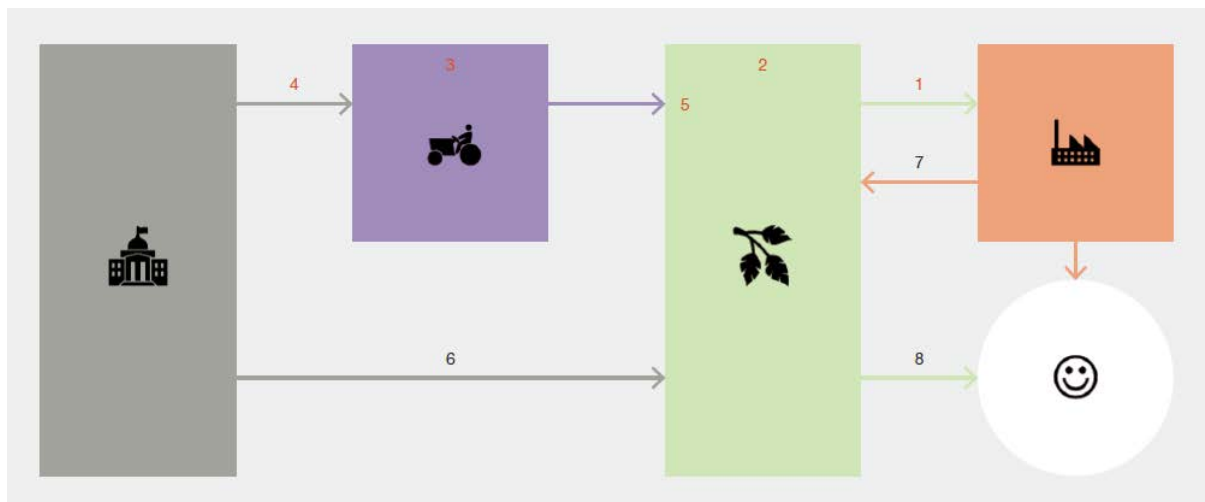


Figure 1.1: Simplified diagram of the sectors and processes addressed by the IPBES Europe and Central Asia policy questions. Red numbers: generic IPBES questions; black numbers: Europe and Central Asia-specific questions. Key to symbols reflecting the IPBES conceptual framework (Díaz, Demissew, Carabias, et al., 2015) (see Section 1.1.5):

Indirect drivers (which, among others, include policy and management); direct drivers (the pressures of human activities); status, trends and futures in biodiversity and nature's contributions to people; indirect drivers (which, among others, include production, consumption & economic development); good quality of life.

End of Box 1.1

1.1.2 Why is this assessment important?

Nature and its contributions to people are fundamental to the existence of humans as a species and for our societies and their future development. Nature and its contributions to people are, however, continuing to decline, largely because of human actions. Of 2,493 species assessed in Europe and Central Asia, 13% are included on the Red List of Threatened Species of the International Union for Conservation of Nature (IUCN), which constitutes 6.5% of the total number of the species included on the IUCN Red List of Threatened Species, globally (IUCN, 2017). The IPBES Regional Assessment for Europe and Central Asia responded to the need to establish a broader understanding of nature and its contributions to people for the past, present and future through an evidence base in support of effective options for policies and actions to maintain ecosystem integrity. The assessment analyses the relationship between nature and people for the region, based on the latest knowledge and the inclusive IPBES approach. It informs future decisions through a comprehensive analysis of the dynamics of, and interplay between, biodiversity and ecosystems (or nature), their drivers, and their contributions to people. It also identifies opportunities for sustainable development and good quality of life arising from nature.

1.1.3 Review of previous assessments

Previous global assessments on the status of nature and its contributions to people showed that the levels or quality of both are declining (Leadley et al., 2013; Millennium Ecosystem Assessment, 2005). Over the past 50 years, humans have changed ecosystems more rapidly than ever before; 60% of ecosystems are degraded and often overexploited, and pressures on nature are increasing despite the growing number of responses to tackle biodiversity loss (Butchart et al., 2010; Leadley et al., 2013; Millennium Ecosystem Assessment, 2005; Tittensor et al., 2014). Effective responses can be achieved by mainstreaming nature, and its importance to good quality of life, at all societal levels, as in the Strategic Plan for Biodiversity 2012-2020 and its Aichi Biodiversity Targets (CBD, 2010b).

Overall, the state of nature (biodiversity and ecosystems) is deteriorating in Western, Central and Eastern Europe (see for example: European Commission (2015); EEA (2015)). Approximately, 60% of the European Union-level species assessments and 77% of the European Union-level habitat assessments indicate an unfavourable or deteriorating status (EEA, 2015b; European Commission, 2015b). Nevertheless, some species are returning to Western, Central and Eastern Europe after long periods of absence, for example, the European Bison and the Eurasian Beaver (Batbold et al., 2016; European Commission, 2015b; Olech, 2008).

The state of nature is also deteriorating in Central Asia (Appleton et al., 2012; Zoi International Network, 2011) (**Figure 1.2**). Its most distinctive species are, and have been, heavily impacted. For example, the last tigers in the region are thought to have been killed in the 1950s; the snow leopard is extremely rare; and the saiga antelope is critically endangered (Mallon, 2008; Zoi International Network, 2011). Some positive signs are, however, observed in the development of policies for conservation and the expansion of protected areas (**Figure 1.2**).

Of the 54 countries in Europe and Central Asia, only one has not submitted a fifth national report³ to the Convention on Biological Diversity. Other national biodiversity or ecosystem assessments are available for the majority of the Europe and Central Asia countries with an updated list of current assessments available through IPBES (see <http://catalog.ipbes.net/>).

³ The fifth national reports provide, among other aspects, an update on the national status and trends of, and threats to, biodiversity, using national biodiversity indicators and also an assessment of the progress towards the Aichi Biodiversity Targets and the implementation of the Strategic Plan for Biodiversity 2011-2020.

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375 **Figure 1.2: Summary of the trends on the status of nature (biodiversity and ecosystems) in Central**
 376 **Asia (Source: Zoi International Network, 2011).**

377 Since the Millenium Ecosystem Assessment (2005), the body of scientific knowledge on nature and its
 378 contributions to people has quadrupled by the end of 2016 (based on a Scopus search using
 379 “biodiversity” and “ecosystem services” as search terms). The Regional Assessment for Europe and
 380 Central Asia covers previous and new knowledge in a synthetic assessment of the region. Scientific
 381 and societal debate on the valuation of nature and its contributions to people has generated new
 382 insights. For example, publications about “human wellbeing” increased rapidly after the Millennium
 383 Ecosystem Assessment concluded in 2005 and continued to rise after the publishing of the initial “The
 384 Economics of Ecosystems and Biodiversity” (TEEB) reports in 2010 (see **Figure 1.3**).

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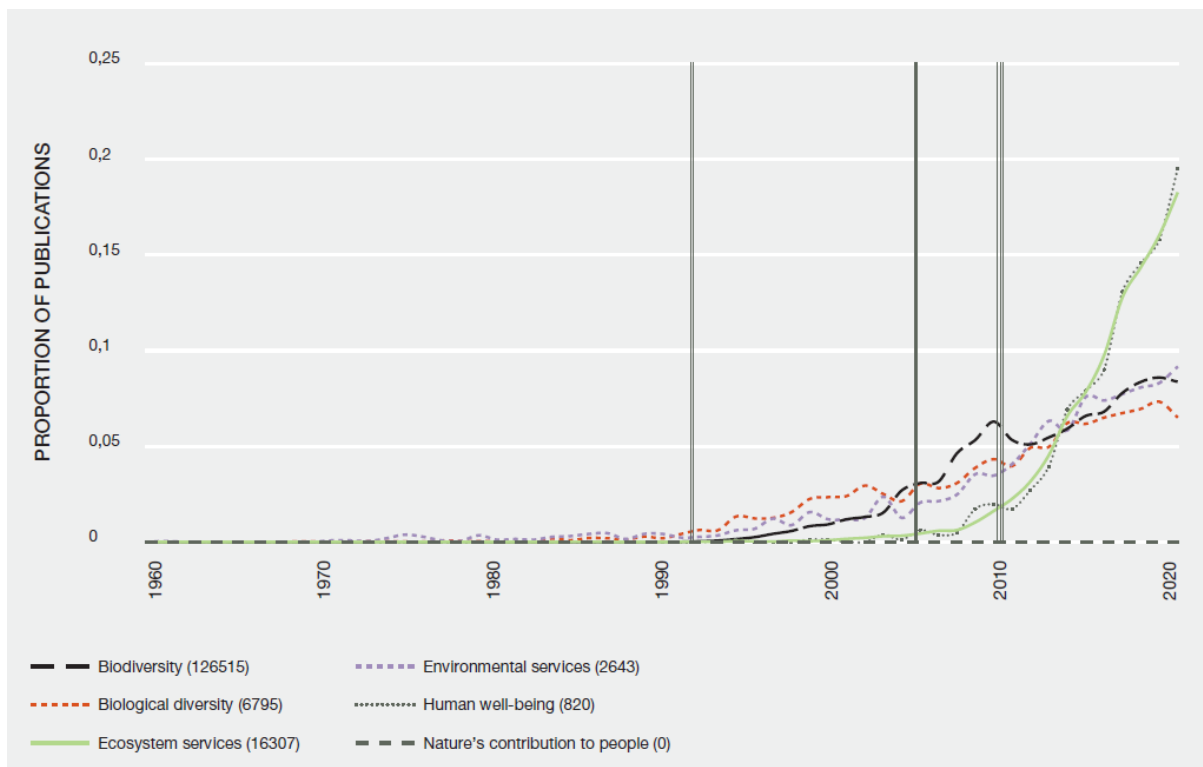


Figure 1.3: Changing frequency of keywords in the scientific literature to reflect the prevalence of these terms. Data generated from the Scopus database for all publications from 1960 to 2016 (using search terms as shown in the legend, except “human well-being” AND each of the other terms). The actual number of publications associated with each search term is shown in parentheses. The y-axis shows the proportion within each search term published in each year to show the changing use of search terms through time. Each vertical black line represents a key moment relevant for global policy: the Rio Conventions in 1992 (double thin line); Millenium Ecosystem Assessment (single thick line); The Economics of Ecosystems and Biodiversity (three thin lines).

1.1.4 Why another assessment? The added value of the Regional Assessment for Europe and Central Asia

The Europe and Central Asia assessment aims to be broad and inclusive, builds on previous assessments and takes into account not only new research, but also evolved insights. Previous assessments covered various aspects of nature, nature’s contributions to people and good quality of life. Some of these assessments were more inclusive in terms of world views and diverse values than others, but this was done implicitly, e.g. Millenium Ecosystem Assessment (2005). Nature has mainly been linked with a limited set of instrumental values, e.g. (TEEB, 2010a). Although the valuation field has been developing rapidly, most assessments have emphasized traditional economic (monetary) valuation approaches, e.g. (TEEB, 2010a). More recent regional assessments (e.g. (Jacobs et al., 2016)) and research projects, (e.g. “OPERAs,” 2017; “Operationalisation of Natural Capital and Ecosystem Services,” 2017) have been more inclusive of stakeholders and diverse values. The Regional Assessment of Europe and Central Asia explicitly covers the diverse values connected to nature, nature’s contributions to people, and good quality of life (see **Figure 1.4**) according to the IPBES conceptual framework (see Section 1.1.5) (Díaz et al., 2015; Pascual et al., 2017). These values range from values of nature itself (individual organisms, biophysical assemblages, biophysical processes);

regulating, material and non-material contributions of nature to people; new options for nature's contributions to people; and good quality of life from cultural, societal and individual perspectives.

The policy questions summarising Government requests (see Section 1.1.1) require these diverse values to be addressed, with a main focus on nature's contributions to people and to good quality of life (Figure 1.4). Based on the conceptual framework, the Europe and Central Asia assessment aims to have a balanced representation of these different values. This responds more closely to policy demands and is a novelty of IPBES compared with previous assessments.

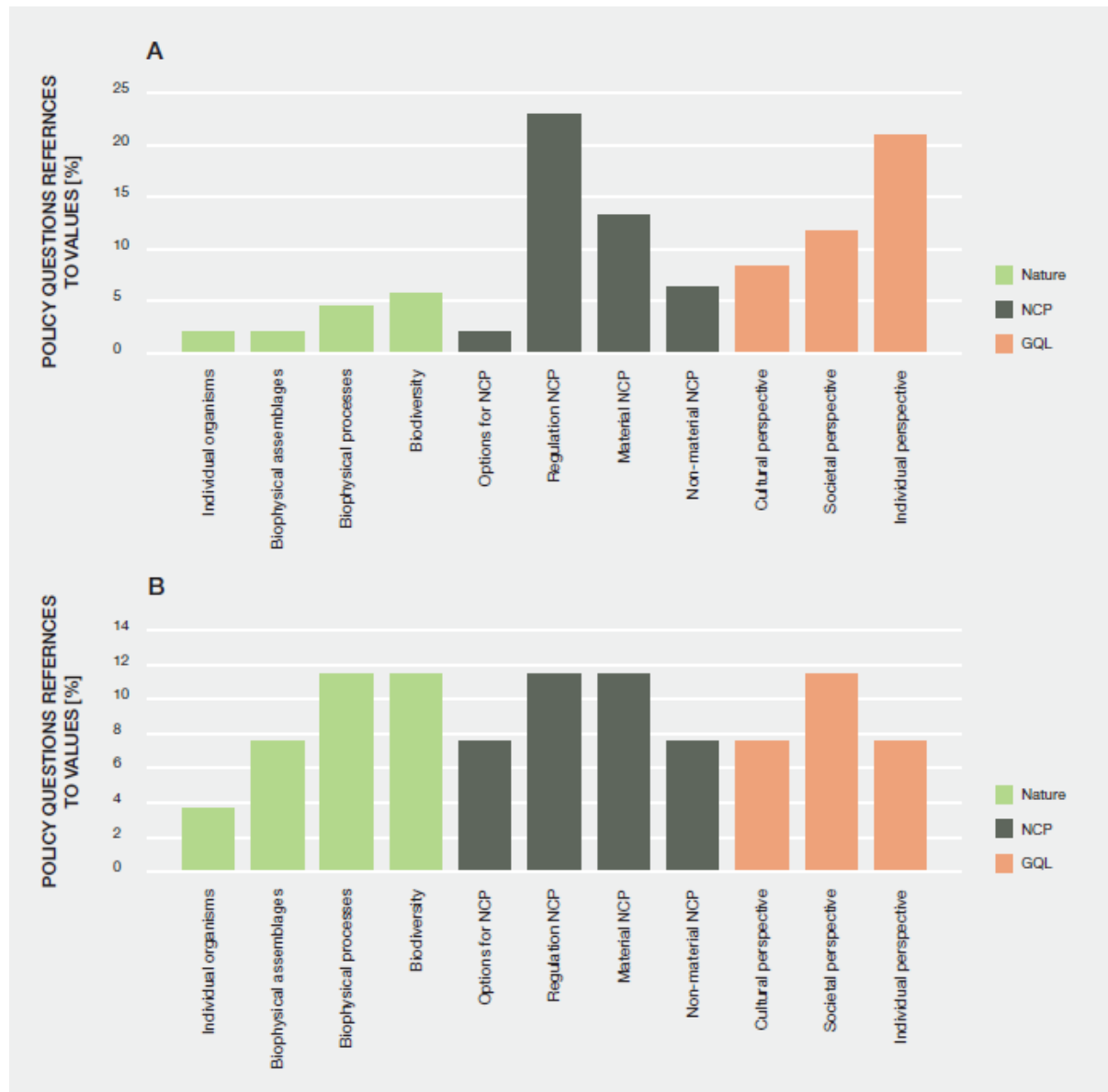


Figure 1.4: A: Europe and Central Asia policy questions explicitly refer to diverse values. Bars are based on the number of times value targets are mentioned in the eight Europe and Central Asia policy questions. Policy questions are described in Section 1.1.1; B: The Regional Assessment for Europe and Central Asia effectively covers diverse values. Bars based on cross-validated coverage estimates per value focus and per chapter. NCP: Nature's contributions to people; GQL: Good quality of life. Value foci are introduced in Section 1.5.2.

IPBES assessments are the first assessments on nature and its contributions to people to have been through a formal process to establish political legitimacy and to respond directly to requests from

Governments. Of the 54 countries in Europe and Central Asia, 38 are members of IPBES. Moreover, many stakeholders from the region are part of IPBES's stakeholder network, including learned societies, NGOs, and representatives of indigenous and local communities. The assessment also uses a broad variety of knowledge and evidence sources beyond the natural sciences. All chapters consider indigenous and local knowledge (ILK). The assessment is therefore a legitimate and credible analysis relevant to all levels of governance and decision-making, from multinational organizations, through national Governments to the local level, and relevant to a broad audience.

1.1.5 The IPBES conceptual framework

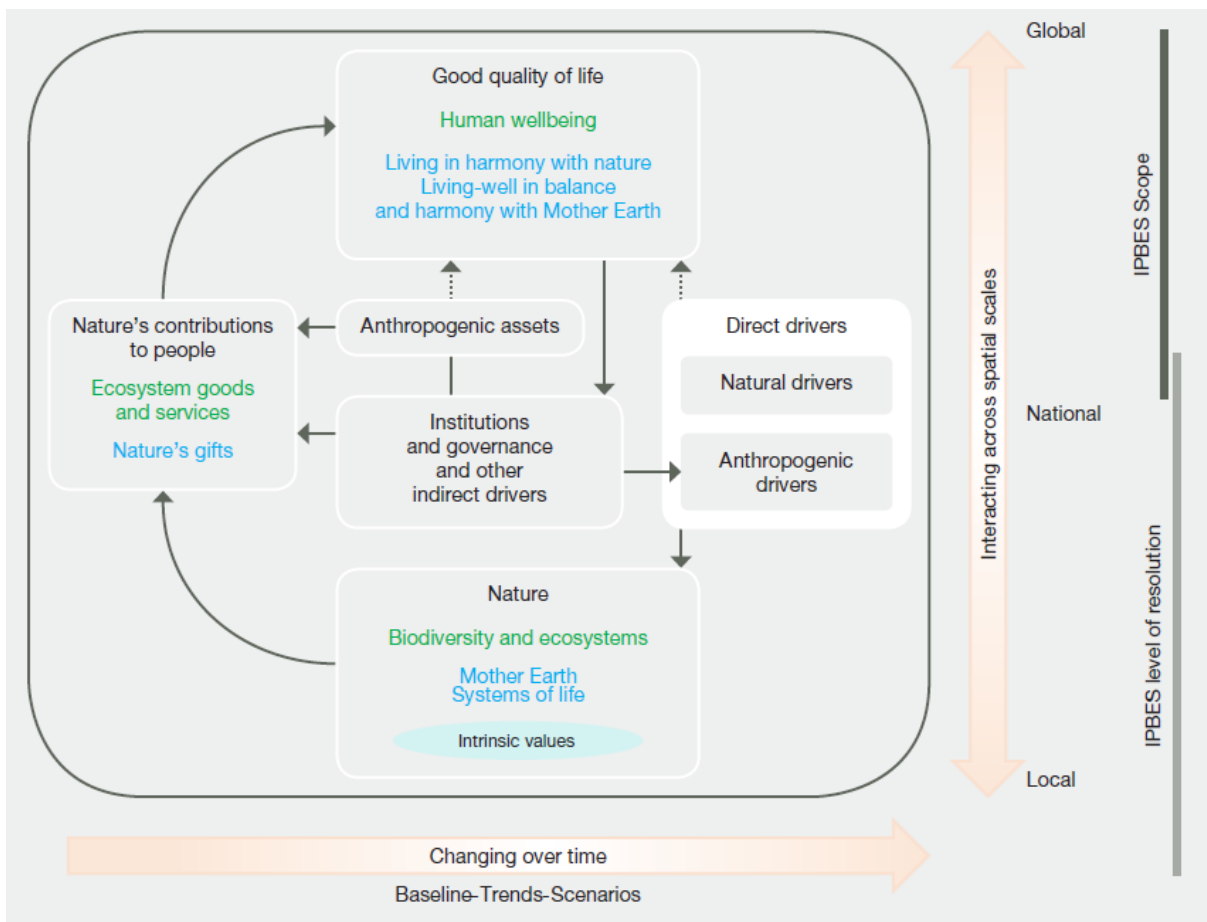
IPBES has developed and approved a conceptual framework to summarize the components of the system comprised of people and nature, and the relationships between them (Díaz et al., 2015; UNEP, 2014). **Figure 1.5** is a simplified version of the conceptual framework as adopted by the second meeting of the IPBES Plenary. It retains all the essential elements, but some of the detailed wording for each of the elements has been removed from the boxes to improve readability.

The IPBES conceptual framework provides structure and comparability to the assessments that IPBES is producing at different spatial scales, on different themes, and in different regions. It was developed through a transparent and participatory process and explicitly considers diverse scientific disciplines, stakeholders, and knowledge systems, including indigenous and local knowledge. It is essential for interpreting the finding of the Regional Assessment for Europe and Central Asia and links strongly to the diverse values discussed in Section 1.5.2. The framework also provides common terminology for use across IPBES assessments. The six chapters of the Regional Assessment for Europe and Central Asia map onto the conceptual framework as indicated in **Table 1.1**.

Integrative, but explicit conceptual frameworks are particularly useful tools in fields requiring interdisciplinary collaboration. They help to cope with complexity by clarifying and focusing thinking about relationships, and supporting communication across disciplines and knowledge systems and between knowledge and policy. The main elements of the IPBES conceptual framework are:

- **Nature:** the natural world with an emphasis on the diversity of living organisms and their interactions among each other and with their environment.
- **Anthropogenic assets:** including knowledge, technology, work, financial assets, and built infrastructure that, together with nature, are essential in the co-production of nature's contributions to people.
- **Nature's contributions to people:** all the contributions of nature, both positive and negative, to the quality of life of humans as individuals and societies.
- **Drivers of change:** all external factors that affect nature, and, consequently, the supply of nature's contributions to people. The conceptual framework includes drivers of change as two of its main elements: institutions, governance systems and other indirect drivers on the one hand and direct drivers on the other:
 - Institutions and governance systems are among the root causes of the direct anthropogenic drivers that affect nature. They include systems of access to land, legislative arrangements, international regimes (such as agreements for the protection of endangered species) and economic policies.
 - Direct drivers, both natural and anthropogenic, affect nature directly. Direct *anthropogenic* drivers result from institutions and governance systems and other indirect drivers. They include human-caused habitat conversion and climate change, pollution, exploitation of ecosystems and species, and species introductions. Direct *natural* drivers also directly affect

- anthropogenic assets and quality of life (e.g. a volcanic eruption can destroy roads and cause human deaths), but these impacts are not the main focus of IPBES.
- **Good quality of life:** the achievement of a fulfilled human life. It is a highly values-based and context-dependent element comprising multiple factors such as access to food, water, health, education, security, and cultural identity, material prosperity, spiritual satisfaction, and freedom of choice. A society's achievement of good quality of life and the vision of what this entails directly influences institutions and governance systems and other indirect drivers and, through them, all other elements in the conceptual framework.



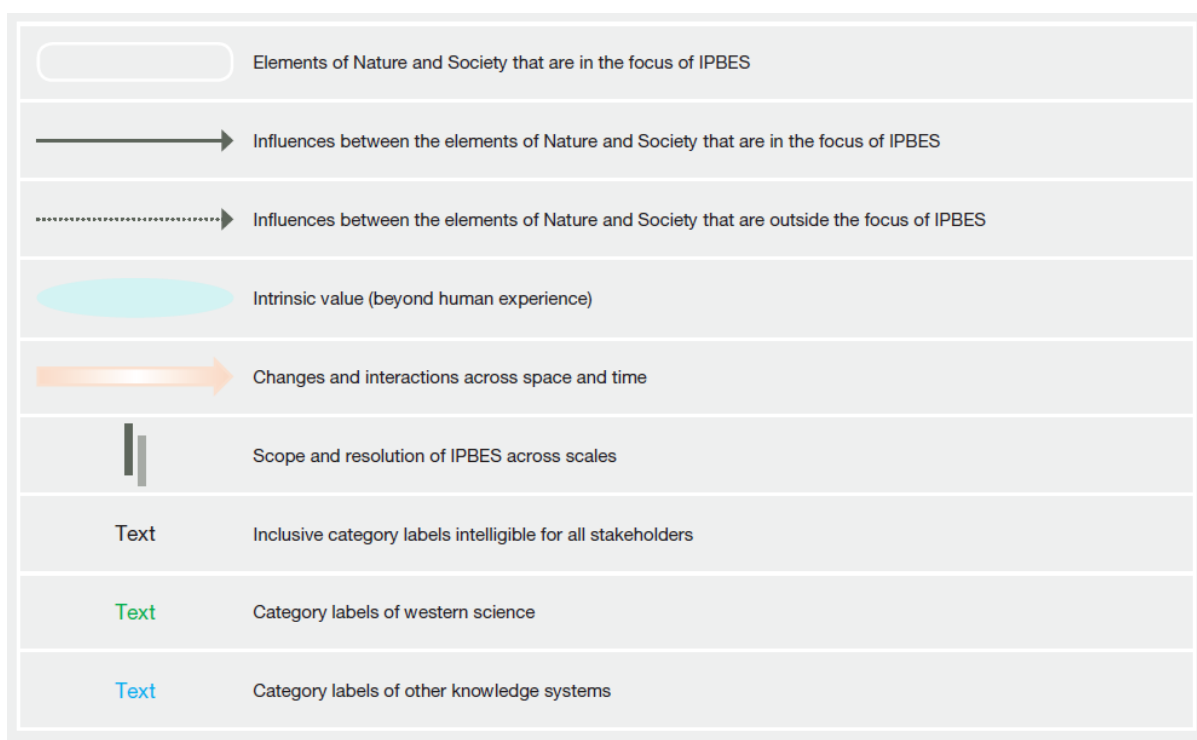


Figure 1.5: The IPBES conceptual framework (Díaz, Demissew, Carabias, et al., 2015).

The inclusive nature of the conceptual framework, in terms of contributions, stakeholders, knowledge systems and worldviews, necessarily requires the consideration of diverse value systems. Value systems vary among individuals, within groups, and across groups at various temporal and spatial scales. For example, some nations tend to be more dominated by value systems that prioritize individual rights and others by value systems that prioritize collective and community-level values (Díaz et al., 2015). The Regional Assessment for Europe and Central Asia covers the diverse values of nature, including non-anthropocentric, instrumental and relational values. This involves a range of different data and information sources that typically are not found within a single assessment, such as biophysical and socio-ecological models, socio-economic and socio-cultural valuation and qualitative data such as that based on discursive accounts and social elicitation methods. Accounting for the differences in data availability, and their representativeness for, and acceptance by, different disciplines is challenging both in synthesizing findings and in attributing confidence to these findings.

Table 1.1: How the IPBES conceptual framework maps onto the chapters of the Europe and Central Asia assessment.

Chapter	Conceptual framework boxes and fluxes
Chapter 1: Setting the scene	All the boxes and fluxes of the conceptual framework
Chapter 2: Nature's contributions to people and quality of life	"Nature's contributions to people" and their relation to "good quality of life"

Chapter 3: Status, trends and future dynamics of biodiversity and ecosystems underpinning nature's contributions to people	"Nature" and its relation to "Nature's contributions to people"
Chapter 4: Direct and indirect drivers of change in biodiversity and nature's contributions to people	"Institutions and governance and other indirect drivers" and their relation to "direct drivers"
Chapter 5: Current and future interactions between nature and society	All the boxes and fluxes of the conceptual framework
Chapter 6: Options for governance and decision-making across scales and sectors	"Institutions and governance and other indirect drivers" and their effects on all other boxes of the conceptual framework

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503

1.2 Relevant stakeholders

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1.2.1 Who does this assessment concern?

505 Governments and multilateral environmental agreements requested that the Regional Assessment for
506 Europe and Central Asia be conducted. It is therefore directly relevant to Governments, as it answers
507 their specific policy questions (see Section 1.1.1). Nevertheless, nature's contributions to people have
508 effects not only at different ecological scales, but also at different organizational scales, from the
509 individual to the community, and administrative scales from the local to the international. For
510 instance, material contributions may be of interest to indigenous peoples and local communities (e.g.
511 timber), but the same source can also be of interest at higher institutional levels (e.g. carbon
512 sequestration). Furthermore, national or global stakeholders and indigenous and local communities
513 may differ in their emphasis on the conservation of nature and sustainable use, and the enhancement
514 of the aesthetic, cultural heritage, natural and recreational quality of their living environment. In
515 addition, especially for indigenous peoples and local communities, ecosystems may also be a places
516 of rituals and a point of reference in cultural and spiritual narratives (Hein, 2006; Reyers et al., 2013;
517 Raudsepp-Hearne & Peterson, 2016).

518 Many stakeholder groups were directly or indirectly involved in the production of the Regional
519 Assessment for Europe and Central Asia - directly through data and knowledge sharing and reviewing
520 drafts, and indirectly by encouraging, facilitating and supporting the participation of scientists and
521 knowledge holders within the assessment (see also the preface for the assessment procedure and
522 Section 1.5). The assessment experts obtained stakeholder knowledge, views and values through
523 discussions at IPBES stakeholder days, IPBES Plenary meetings and by stakeholders reviewing drafts.
524 In addition, grey literature was analysed and knowledge holders were consulted as experts. By
525 including different knowledge and data sources and values, and allowing for a transparent process, an
526 assessment gains credibility, legitimacy and relevance (Cash et al., 2003).

527

528

1.2.2 Which benefits are available to stakeholders?

529 Stakeholder incentives and benefits associated with involvement in the assessment include the
530 opportunity to contribute to the IPBES process, the inclusion of stakeholder-derived data and the
531 acquisition of knowledge. Consequently, the capability to develop partnerships and to learn from

insights from other disciplines increases as well as the potential for capacity building, identified from an IPBES stakeholder analysis survey (IPBES/5/INF/16: Implementation of the stakeholder engagement strategy). Stakeholder groups have specific information needs, but also derive different benefits from the insights and knowledge contained within the assessment (see discussion below). Stakeholders acknowledge that the IPBES process in general, and the Regional Assessment for Europe and Central Asia in particular, bring together different disciplines and stakeholder groups. In doing so, the participants gain insights into diverse conceptualisations of values and social and political contexts leading to the building of partnerships.

Regional (supra-national) Governments and national Governments. The questions posed by Governments are outlined in Section 1.1.1. The assessment offers insight into the best indicators to assess the status and trends of biodiversity and nature's contributions to people, as well as pinpointing data gaps. It also highlights the necessary responses and the potential opportunities and differences between countries.

Subnational governments: Subnational and local public actors have an interest in opportunities for investment in nature that leads to social and economic benefits. They request independent sources of information about how nature can help society to cope with future challenges such as water scarcity, climate change or air pollution and to enhance the living standards of citizens.

Multilateral environmental agreements and United Nations agencies: United Nations agencies have a range of scientific advisory processes in addition to being responsible for multilateral environmental agreements. Information provided through the assessment can contribute substantially to informing these processes. Multilateral environmental agreements have subsidiary bodies or other mechanisms to consider scientific and technical evidence. The information provided by the assessment contributes to some of these subsidiary bodies and mechanisms as a means of improving their effectiveness.

Intergovernmental organizations: Policy-relevant information provided by the assessment is also an important source of information about nature, its contributions to people, and good quality of life, for broader intergovernmental organizations.

Practitioners and implementers: Many organizations, including NGOs, and individuals involved in the operational management of nature and its contributions to people in practice can access IPBES products, such as policy support tools, and learn how these can be applied to conservation and sustainable use of nature (Decision IPBES-3/4: Communications, stakeholder engagement and strategic partnerships). The assessment provides examples and case studies for the use of such tools.

The scientific community: The assessment supports the scientific community in gathering information from different data sources and regions to highlight knowledge gaps and provide evidence to fill these gaps.

Indigenous Peoples and Local Communities: Indigenous peoples and local communities are the main users and caretakers of nature and its contributions to people over large areas of Europe and Central Asia. Their understanding of nature, drivers, futures and policies can help to develop subregional or local actions and policies that are more relevant and acknowledge indigenous rights. The assessment serves as an important forum for discussion and knowledge co-production, which is urgently needed to improve the livelihoods of indigenous peoples and local communities.

Private Sector: Business is often based on the use of natural resources and frequently has an impact on ecosystems, but the private sector can also find opportunities by aligning business activities with

benefits to nature. To achieve this, the private sector requires insight into how to align their actions with goals of conservation and sustainable use by better recognizing and responding to interdependencies and impacts on nature (TEEB, 2010b). Businesses are also decision-makers and have an important role to play in the conservation, use and management of biodiversity and ecosystems upon which they depend. The information within the assessment supports the implementation of sustainable solutions that avoid, minimize or offset impacts on ecosystems and identifies the interdependencies between business and ecosystems.

The general public: “The people who are affected and those who provide resources are increasingly asking for evidence that interventions improve ecosystem services and human well-being.” (Carpenter et al., 2009). The assessment provides the general public with an independent source of knowledge.

1.2.3 Policy instruments for different stakeholders

An important function of the IPBES process is to support policy formulation and implementation by identifying policy relevant tools and methodologies. Stakeholders have a number of options and instruments available to protect and enhance biodiversity and ecosystem services. Policy instruments may take many different forms including environmental standards and regulation, economic incentives, education, capacity building and awareness raising (a non-exhaustive list is found in IPBES/4/INF/14: Information on work related to policy support tools and methodologies (deliverable 4 (c))). Policy instruments are often referred to as being designed by public authorities, but IPBES embraces design by all stakeholders including citizen organizations and indigenous peoples and local communities (IPBES/4/INF/14).

Four different categories of policy instruments for different actors have been identified in Chapter 6 (adapted from IPBES/4/INF/14):

1. Legal and regulatory instruments, for example implementing and articulating laws and regulations, planning instruments;
2. Economic and financial instruments or price-based instruments, for example fiscal instruments, and quantity-based instruments such as tradeable permits;
3. Social and information-based instruments with an emphasis on the intertwined relationship between ecosystems and socio-cultural dynamics, including: (i) information related instruments such as eco-labelling, and environmental education; (ii) self-regulation and corporate social responsibility; and (iii) enhancement of the collective actions of local communities;
4. Rights-based instruments and customary norms, that integrate rights, norms, standards and principles into policy, planning and implementation, for example by reconciling conservation and human rights standards, e.g. the rights and institutions of indigenous peoples, and heritage sites.

Various public and private actors can choose from a wide range of policy instruments to achieve their objectives. Traditionally, centralised and decentralised Governments have shaped environmental and biodiversity conservation policies, largely building on legal and regulatory instruments. Such hierarchical decision-making has increasingly been complemented by other governance modes addressing and involving private actors through economic, financial, social and information-based instruments. Furthermore, rights-based instruments and customary norms offer ways to reconcile human rights standards, and to foster complementarity with human well-being (IPBES/4/INF/14). The latter category is especially important to help develop regionally and locally relevant actions and

policies for indigenous peoples and local communities. In practice, policy instruments are usually applied in combination in policy mixes (see Chapter 6).

Capacity building is another important function of the IPBES process. As **Figure 1.6** illustrates, capacity building typically represents the development and strengthening of human and institutional resources through the ability to perform functions, to solve problems, and to achieve objectives at individual, societal and institutional levels (United Nations, 2006). Addressing both public and private sectors plays a key role in successful capacity building processes. The Regional Assessment for Europe and Central Asia supports capacity building through new knowledge generation, particularly in the identification and quantification of nature's contributions to people and to good quality of life (Díaz et al. 2015). New knowledge can result, for example from long-term biomonitoring on permanent plots, from comparative studies or from experiments. Such records have the potential to contribute to more informed assessments of future changes in biodiversity patterns. By raising awareness at the individual level, such information facilitates appropriate strategies, plans and programmes developed at higher institutional levels.

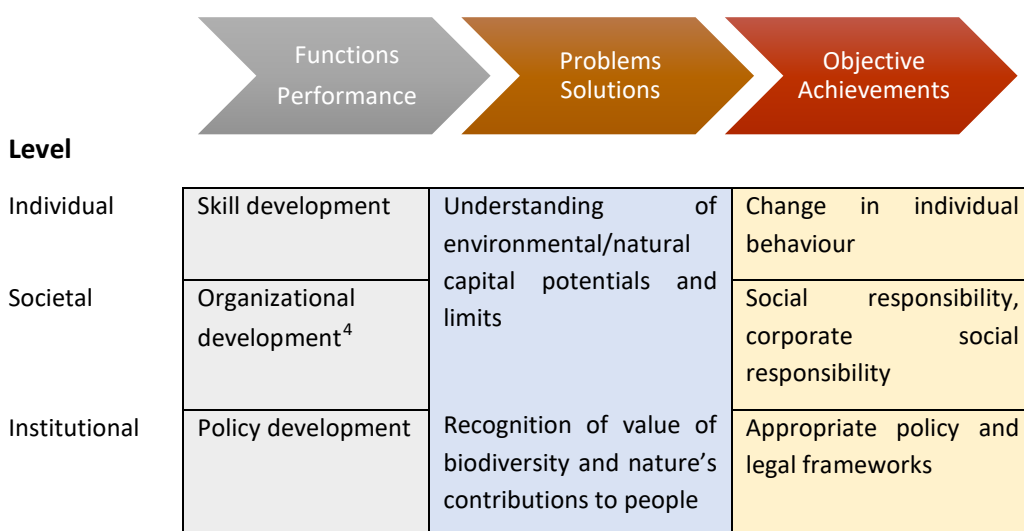


Figure 1.6: Potential contribution of the Regional Assessment for Europe and Central Asia to capacity building. Source: own compilation.

Education also plays an important role in supporting societal choices that affect biodiversity and ecosystem services. Stakeholders can promote the work done in the assessment through local and region-wide networks and help by disseminating information to relevant communities. In this way,

⁴ Organizational development: a body of knowledge and practice that enhances organizational performance and individual development.

the assessment will raise awareness for important biodiversity and ecosystem issues across stakeholder groups, and across geographic locations.

1.3 Description of the region

This section introduces the basic characteristics of the Europe and Central Asia region, including the geographic area, the subregional structure, the geographical characteristics including the region's main ecosystem types (units of analysis), together with their most important societal trends in recent history. The basic facts necessary for interpreting the findings of later chapters are introduced.

1.3.1 Overview of the region

Europe and Central Asia encompasses four subregions (see **Figure 1.6**) and 54 countries (see **Table 1.2**). These countries vary greatly in size, including the largest and smallest on Earth, have diverse geography and history, but also common properties in terms of geography and climate, history and social systems. The region shares many cultural norms and historical features reflected in some similarities in land use, environmental history, and nature and its contributions to people. Nevertheless, the region encompasses high heterogeneity in natural and socio-cultural aspects. The seas that surround the region are also very heterogeneous in terms of temperatures, currents, nutrient availability, depths and mixing regimes.

In the assessment, we refer to the IPBES subregions where the data fully covers one or more of them. However, the data shown often represents other divisions, mainly the European Union or “Continental Europe” (sensu European Environment Agency). This includes Western and Central Europe, excluding Anatolia and Israel, and Eastern Europe to a eastern border following the Ural mountains, the river Ural to the Caspian Sea, and a southern board to the Manych valley to the Sea of Azov and the Black Sea, and the Bosphorus. When referring to Europe we therefore refer to the geography just illustrated, recognizing that not all data sources will perfectly match this geography. Otherwise we refer to IPBES subregions (**Figure 1.7**).

Table 1.2: The subregions and countries covered by the Europe and Central Asia assessment

Subregion	Countries
Western Europe	Andorra, Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Liechtenstein, Luxembourg, Malta, Monaco, Netherlands, Norway, Portugal, San Marino, Spain, Sweden, Switzerland, United Kingdom of Great Britain and Northern Ireland
Central Europe	Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Montenegro, Poland, Romania, Serbia, Slovakia, Slovenia, The former Yugoslav Republic of Macedonia, Turkey
Eastern Europe	Armenia, Azerbaijan, Belarus, Georgia, Moldova (Republic of), Russian Federation, Ukraine
Central Asia	Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan



Figure 1.7: Map showing the Europe and Central Asia region with the four subregions recognized by IPBES, and the surrounding seas.

Europe and Central Asia's climatic zones range from polar through temperate to subtropical (Peel et al., 2007). In terms of area, large parts of the region lie in the subarctic and humid continental climate zones, but most of the human population lives in temperate (oceanic, Mediterranean or continental) climates (European Commission, 2017a). Large-scale climate zonation is influenced by many factors from cold and warm ocean currents at the continental scale, to elevation, slope or urban climate islands at the local scale. A large portion of Europe and Central Asia is highly fragmented in terms of geomorphology by mountain ranges and lake and sea coasts and major river systems. Most of Eastern Europe and Central Asia are lowlands or plateaus; while highly variable local conditions create a fine mosaic of land use and habitat types for most of Western and Central Europe (van Asselen & Verburg, 2012), including diverse cultural landscapes. Across large areas of sparsely-inhabited land in Eastern Europe and in Central Asia, ecosystems are less modified by local human activity, but nevertheless affected by global change and natural resource extraction (Hansen et al., 2013). The main ecosystems and land use types (known as units of analysis) are described in **Table 1.3** and shown in **Figure 1.8**. These units of analysis are used throughout the assessment as a means of simplifying, through classification, the complexity of nature.

Table 1.3: Main units of analysis for the purpose of the IPBES assessments and comments specific to the Europe and Central Asia region.

Main type	Name	Description
Snow and ice dominated ecosystems	Glaciers	Areas where the terrain surface is constantly covered in ice

Main type	Name	Description
	Nival belt	Areas in mountains with an extremely short growing season (<10 days) and low average annual temperature (<3.5°C)
	Polar deserts	Vegetation covers less than half of the soil surface, dominated by mosses, lichens, algae and rarely vascular plants
Tundra and mountain grasslands	Tundra	Areas with permafrost, with conditions too adverse for forest growth. Dominated by mosses, grasses or dwarf shrubs
	Alpine belt	Not permanently snow or ice covered, low vegetation dominated by grasses, sedges and forbs
	Subalpine belt	Transition between alpine zone and forests or grasslands. High grass meadows, dwarf shrubs, heathlands or short grasslands, subalpine thinned/crooked forests
Temperate and boreal forests and woodlands	Broad-leaved, mixed and coniferous forest	Vegetation dominated by tall trees
Mediterranean forests and scrubs		Highly seasonal vegetation with water stress during part of the year, dominated by needle-leaved or sclerophyllous trees and/or shrubs
Tropical and subtropical dry or humid forest		Subtropical climate, dominated by deciduous, evergreen or mixed trees
Temperate grasslands		Dry or seasonally wet, non-coastal areas with more than 30% vegetation cover, mainly grasses and herbs. Self-sustaining due to fire, aridity or grazing; or secondary, sustained by mowing or grazing
Deserts		Precipitation less than 250 mm/year. Can be cold (with snow cover) or warm (very dry and hot in summer, no snow)
Peatlands		Organic matter accumulation in soil due to limited decomposition, water abundant, specific soil
Urban habitats		Natural and artificial habitats within or close to human settlement. Suburban (with abundant green space), or urban (dominated by built structures and sealed soil surfaces)
Agricultural areas		Human management of vegetation and soil. High, medium or low intensity.
Special systems	Heathlands	Dwarf shrub dominated areas in Atlantic, Subboreal or Continental climate. Developed due to human land use in historic times

Main type	Name	Description
	Caves and other subterranean habitats	Lack of light, trophic dependence on aboveground systems, stable temperature, high humidity, limited supply of organic material. Terrestrial or aquatic, epikarst and endokarst
Marine and freshwater habitats	Deep seas benthic habitats	Deep sea benthic habitats and species inside the exclusive economic zones and deeper than 200 m,
	Shelf and water column	All non-enclosed seas with benthic habitats shallower than 200 m and pelagic habitats
	Enclosed seas and saline lakes	Brackish to hypersaline enclosed water bodies, both temporary and permanent
	Freshwater lakes and streams	Water bodies with salt content below 0.1 g/l

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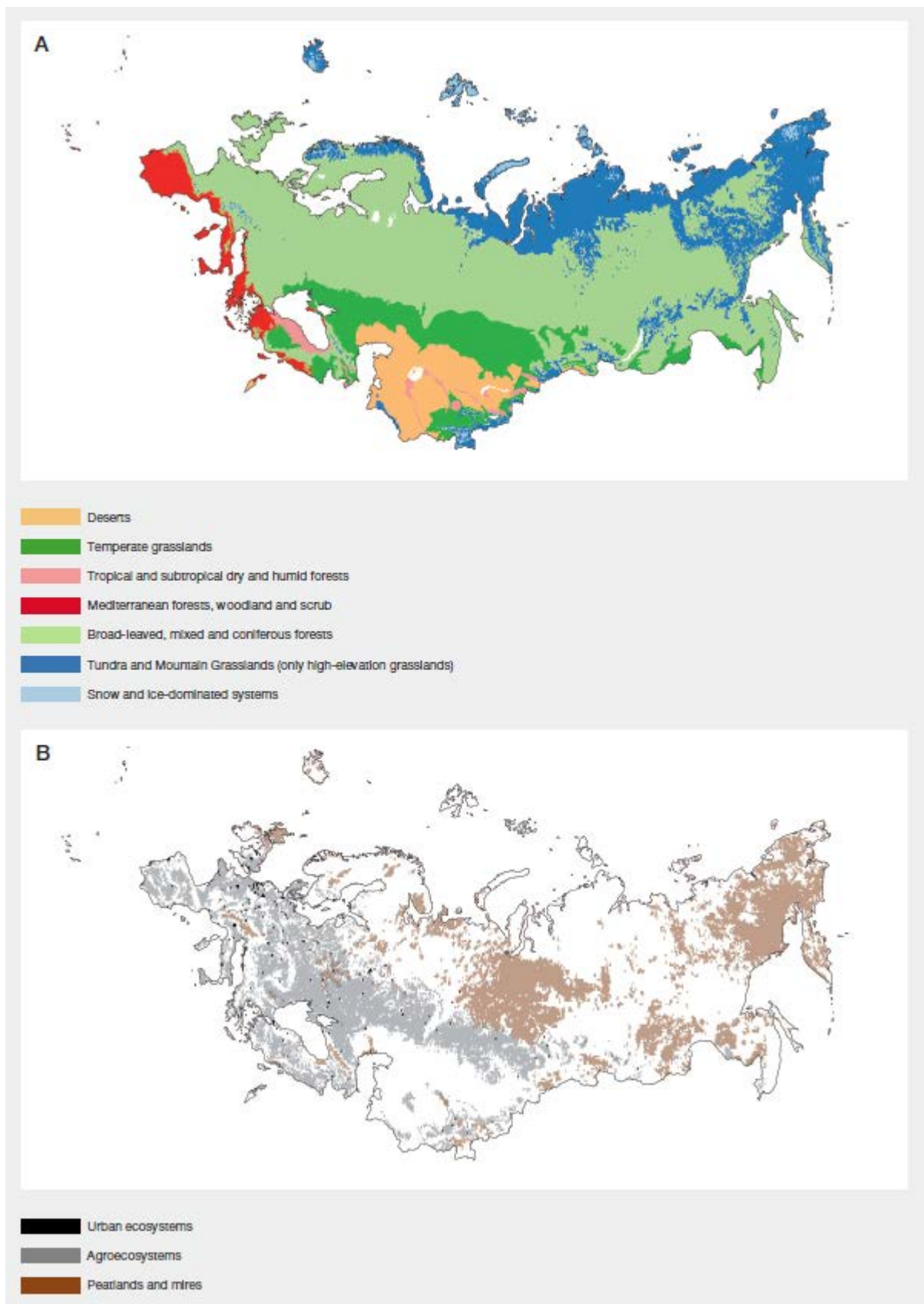


Figure 1.8: Maps of the main units of analysis used in the Regional Assessment for Europe and Central Asia.

Europe and Central Asia is characterised by major human intervention arising from continuous high population densities and a long history of unbroken land management (Ellis et al., 2013). This has led to the most populated parts of the region being strongly modified by people, including the creation of cultural landscapes based on traditional management approaches (Plieninger et al., 2014). Within the subregions there is a large variability in human population density, with a broad trend of less intensive human impact in the eastern parts of the region (**Figure 1.9**). Moreover, the subregions have different time lines of human intervention arising from very different histories (Jepsen et al., 2015). This also reflects heterogeneity in cultures, natural heritage, governance structures, politics, and the implementation of environmental legislation. Small-scale heterogeneity and a high level of fragmentation both in a geographical and a cultural sense is probably the most important difference between most of Europe and Central Asia and some other continental regions. Partial coordination of governance across parts of this region is the role of the European Union and also of the various international treaties.

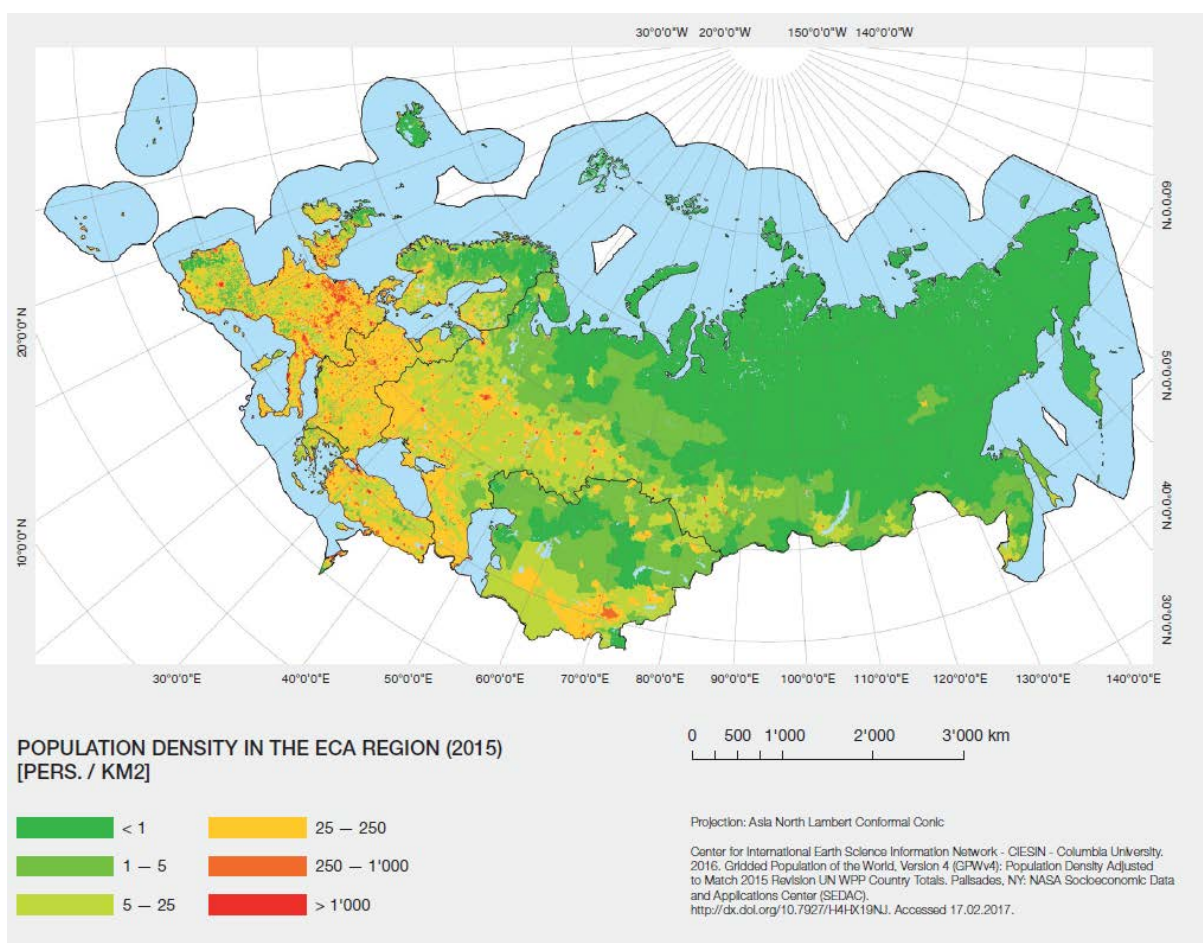


Figure 1.9: Population density across Europe and Central Asia (“Socioeconomic Data and Applications Center (SEDAC),” 2017).

Table 1.4: Indicators of land use in Europe and Central Asia (Source: data.worldbank.org).

Indicator	Western Europe	Central Europe	Eastern Europe	Central Asia
Area (km ²)	3,837,700	2,238,000	20,785,800	4,008,000

Population	421,446,000	200,486,000	217,576,000	69,052,000
Average population density (people/km ²)	110	90	10	17
Urban population%	78	66	71	40
Agricultural land%	37	48	21	75
Forested land %	39	27	43	3

1.3.2 Marine areas of Europe and Central Asia

In terms of marine areas, this assessment focuses on the Exclusive Economic Zones (EEZ) of the countries in the region, therefore mainly marine areas within 200 nautical miles from the shores (unless interrupted by land) are discussed. Since marine units typically bridge several subregions, here they are presented followed by a description of their main habitat types (units of analysis) in an order that is independent of the subregions (see **Figure 1.7**).

North East Atlantic. The European part of the Atlantic Ocean (*sensu lato*, i.e. including North Sea, Irish Sea, English Channel, Iberian coast and Macaronesian Islands) encompasses large latitudinal gradients, extending from the sub-tropics (e.g. Gibraltar at approximately 36°N) to the upper latitudes of Svalbard in the Arctic (e.g. 77°N) and bridging several biogeographic provinces from Arctic to warm temperate systems (Spalding et al., 2007). It includes highly diverse and complex benthic habitats such as hydrothermal vents, seagrass meadows, kelp forests and biogenic reefs (Prather et al., 2013; Smale et al., 2013; Worm et al., 2006). The North East Atlantic is influenced by transcontinental ship traffic in addition to climate change, pollution, fisheries and aquaculture. Shore areas have also been widely altered by human activities in the past, including the building of shorewalls, drainage and infilling of coastal wetlands and pollution via inflowing rivers. Coastal areas are hotspots of urbanization, with about 40% of the Western European population living in coastal areas.

Baltic Sea. The Baltic sea is relatively shallow and brackish, has almost no tide, and experiences intense seasonality in temperature and inflow. It holds both marine and freshwater species, with relatively low species diversity, also influenced by industrialization mainly in its southern part. Human influence is similar or even more intensive than in the North East Atlantic.

Mediterranean Sea. The Mediterranean Sea is one of the largest of the marine units in the Europe and Central Asia region. It is microtidal, oligotrophic, homothermic and highly saline. The Mediterranean is composed of four sub-units, and has its own zonation predominantly influenced by vast watersheds and rivers that flow into them, resulting in a wide diversity of conditions and high biodiversity (Lejeune et al., 2010).

Black Sea (including Azov sea). The Black sea is a medium-sized tideless inland sea with an outlet to the Mediterranean. It is extremely stratified, resulting in a lack of oxygen in the deeper strata. The depth of the thermocline and the anoxic layer depends on seasonality, with changes resulting in major losses of biota. It is a highly sensitive ecosystem dominated by mediterranean species (although less diverse than the mediterranean itself).

Arctic Ocean. The Arctic Ocean has a large area, and is characterized by ice-associated ecosystems. Climate change (especially changes in sea ice) is rapidly changing the situation in the Arctic Ocean, and opening up new opportunities for natural resource exploration and shipping, which are however expected to strongly affect local biodiversity and ecosystem functioning. Species diversity is largely unexplored (Belikov et al., 2011).

North West Pacific. The seas linked to the Russian Far East include a continental shelf, but also very deep basins which have their own circulation, partially connected to the Pacific Ocean. As one of the most highly productive regions of the global ocean (Antonov et al., 2013), these are important fishing areas with high biodiversity, threatened by recent hydrocarbon exploration. Marine mammal diversity is especially important (Artyukhin & Burkanov, 1999; Burdin et al., 2009; Geptner et al., 1976; Hunt et al., 2000; Sokolov & Соколов, 1986; Yablokov et al., 1972).

1.3.3 Marine and inland surface water units of analysis of the Europe and Central Asia region

Shelf and water column. This Unit of Analysis includes all the benthic habitats down to 200m depth and all the water column within the exclusive economic zone of the Europe and Central Asia region. This Unit was sub-divided geographically into the different Seas and Ocean areas described above. Many of the policies regarding the marine environment, e.g. the European Union Marine Strategy Framework Directive (European Union, 2008a) as well as regional cooperation agreements (e.g. (“HELCOM,” 2017; “OSPAR,” 2017)) consider the seas and Oceans separately.

Deep Sea benthic habitats. All benthic habitats inside the Exclusive Economic Zones of Europe and Central Asia countries that are deeper than 200m fall into this category. This is the most widespread habitat type on Earth with rich diversity, but it is not well known or understood. Deep sea habitats and biodiversity contribute important regulating functions and services on a global scale.

Enclosed seas and saline lakes. Saline lakes range from several thousand square kilometers (Caspian Sea) to small ephemeral habitats. Based on their salt content, saline lakes are classified as brackish (salt content in the range 0.1-3.5 g/l), saline (above 3.5 g/l) or hypersaline (above 50 g/l) lakes. The Caspian is large and brackish with high biodiversity and many endemisms. The Aral Sea is now extremely saline and mostly dried up. Smaller saline lakes are typical in endorheic basins and lowland areas mainly in the Mediterranean (Čížková et al., 2013) and continental regions (Comin & Alonso, 1988; EEA, 2002; Izmailova, n.d.; Kazanci et al., 2004; Kortekaas & Vayá, 2009; Kotova et al., 2016; Kulagin et al., 1990; Montes & Martino, 1987; Orlov et al., 2011; Örmeci & Ekercin, 2005; Republic of Turkey, 2014; Stenger-Kovács et al., 2014; Williams, 1981; Zektser, 2000). They are fed by rain and groundwater, with highly variable salinity conditions depending on inflow and evaporation. Brackish lakes can be highly diverse while very saline lakes usually hold only a less diverse flora and fauna, including unique and highly valuable extremophile bacterial diversity (Oren, 2006). Both salinity and ionic composition control species richness and biodiversity, but this is also influenced by ionic composition (Balushkina et al., 2008; Boros et al., 2013; Brucet et al., 2012; Oren, 2006; Ventosa & Arahá, 2009). Both large permanent and small ephemeral saline lakes are important habitats for migratory birds.

Freshwater lakes and streams. Freshwater habitats include both standing and running water, with the Europe and Central Asia region holding almost 60% of the global freshwater volume (Messenger et al., 2016). Many lakes are found in the sub-boreal and boreal zone as relicts of glacial activity. Central and Eastern Europe hold vast drainage basins that feed a system of large rivers (compared with Western Europe, where watersheds are more fragmented, and Central Asia, where the climate is more arid). The overall diversity of freshwater species in Europe and Central Asia was routinely reported to increase towards lower latitudes (Hof et al., 2008). River and lake systems often sustain coastal wetlands which are hotspots of biological production and diversity in the landscape mosaic. Therefore, freshwater habitats contribute importantly to green corridors and networks.

1.3.4 Subregion descriptions of Europe and Central Asia

Western Europe

Western Europe has highly fragmented and diverse landscapes of peninsulas, islands, mountain ranges and riverbasins. The subregion includes a wide range of climatic zones from from polar deserts on Svalbard and Iceland to the most extreme desert, the Negev Desert in Israel, and to subtropical island forests. The climate is typically favourable for agricultural production, except at northern latitudes and in some parts of the Mediterranean, where water is limiting. Hence, agro-ecosystems and forests dominate the landscape. Agro-ecosystems are maintained by human activity, and include croplands, orchards, horticultural systems and managed grasslands. Except for extensive grasslands, these habitats have low species diversity. Agriculture includes intensive cropland production and livestock production on grassland that ranges from intensive pasture to extensive rangelands and mountain meadows. Soils are often over-used in intensive agricultural areas and degraded due to erosion and salinization (Montgomery, 2007; Pimentel, 2006). Forests mainly dominate the high latitudes and altitudes, and can be both managed and semi-natural. Boreal forests have high diversity and provide important services (e.g. carbon sequestration), but are also very sensitive to climate change and management. Temperate forests have a long history of human influence in the region and maintain high biodiversity. Mediterranean forests grow in areas of cool wet winters and hot summers, and are typically evergreen or hard-leaved. These range from forests through shrublands to semi-open heaths depending on climate and disturbance. Mediterranean forests and scrubs have extremely high species richness (ca. 25,000 vascular plant species) with high endemism in spite of being heavily modified in historic times. Alpine and sub-alpine meadows, heaths and shrublands occur in the upland areas, with the actual treeline heavily modified by human activity. These habitats are very diverse with a high level of endemism. Urban and semi-urban areas with sealed surfaces also occupy large areas in the densely populated countries of Western Europe, which also contain two (the London and Paris metropolitan areas) of the four megacities - with more than 10 million inhabitants - in Europe and Central Asia. These ecosystems have high levels of disturbance and pollution, but especially residual habitats such as parks can conserve relics of local natural vegetation and may be relatively diverse. In peat bogs, water-saturated soils result in incomplete decomposition of organic matter, leading to an accumulation of organic-rich soils. These habitats have many specialist species, and are common in the oceanic, sub-boreal and boreal zone, but more rare towards the continental and mediterranean regions. Wetlands connected to lakes and rivers are often significantly diminished and modified by water regime regulations. Subterranean habitats are dark systems, which depend trophically on above-ground systems. They have many endemic species that are not well studied, but are extremely sensitive to environmental change.

The historic transition from self-sustaining agricultural systems to industrialized monocultures with high inputs (chemical and mineral inputs, energy and machinery) has led to the transformation of mosaic landscapes into homogeneous agricultural areas where nature and its contributions to people have relatively low value (Mazoyer & Roudart, 2006). The industrial revolution starting in the 18th century, and associated rapid urbanisation, have also had a profound impact on the landscapes of much of Western Europe (Jepsen et al., 2015). More recent land use trends have seen a reduction in agricultural area, especially for cropland, and increases in forest areas. This has happened because of the productivity gains of the green revolution, but also because of increasing imports of food and other commodities causing land use change in other parts of the world (Meyfroidt et al., 2010).

Western Europe is the most densely populated subregion of Europe and Central Asia, with half of the total population of the subregion living on approximately 10% of its terrestrial surface. Worldviews and value systems are highly diverse. Many countries in the subregion are deeply rooted in democracy

where individual human rights are at the centre of those worldviews and values. During the 20th century relatively multi-cultural societies developed with diverse, often contrasting worldviews among citizens. Very large ecological footprints led to a strong increase in environmental awareness. Lifestyles and consumption are rapidly globalizing, but local products and local cultural keystone places are gaining increasing recognition. Traditional lifestyles have almost disappeared, but there are movements toward a new generation of farmers who are more conscious of sustainability.

Fifteen of the 24 countries within Western Europe are members of the European Union; the others retain strong cultural and trade links to the European Union. Hence, environmental policy in this subregion is dominated by European Union legislation, although European Union member States determine how European Union directives are implemented at the national scale, and non-member States define their own environmental policies, albeit influenced by the European Union approach. There is a strong political will within the European Union to use policy to conserve natural and cultural heritage. This is demonstrated by the large number of ecologically-oriented European Union policies, including the Biodiversity Strategy, the Habitats Directive, the Marine Strategy Framework Directive and the Water Framework Directive, amongst others. However, some other European Union sectoral policies have had negative impacts on biodiversity and ecosystem functioning in the past, such as the Common Agricultural Policy's subsidising of intensive agriculture. In addition to the strong political will, there is strong public support for, and interest in, biological conservation across Western European societies.

The Western European region supports a wide range of conservation measures and marine protected areas driven largely by the European Union Habitats Directive. The European Environment Agency 2015 State of the Seas report (p. 125), estimates that, as of 2012, about 4% of European Union marine areas were part of the Natura 2000 Network. However, given the vast biogeographic and geopolitical scope of Western Europe, there is a range of long-standing cumulative environmental pressures (e.g. centuries of coastal habitat alteration and fishing), to more emerging challenges, in particular those associated with climate change. Key examples, within Western Europe include: changes in sea-surface temperature (Philippart et al., 2011) and poleward species migrations, as well as declining polar sea-ice and the opening of Arctic shipping areas (Wassmann & Reigstad, 2011). Various countries provide ongoing regional management plans for respective seas, e.g. Norway for the Norwegian Sea and Barents Sea (Norwegian Ministry of the Environment, 2012).

Western Europe has many countries with high levels of development that is commensurate with high levels of consumption, in terms of both the amount of consumption, e.g. (Alexander et al., 2016), and the variety of products consumed. This has had a profound effect on the ecosystems of Western Europe, which are all under strong human influence (see Figure 1.10). The general trend of habitat loss and deterioration (Birdlife Europe and Central Asia, 2015; European Commission, 2015b) has also reached Alpine and sparsely-populated Arctic areas, but even these are under pressure from tourism, natural resource exploitation and global change. Meanwhile, there is an increasing trend towards restoring natural habitats, with many successful examples. Western Europe is a net "ecological debtor" (with the exception of Sweden, Norway and Finland) being dependent on the import of external resources, therefore causing environmental impacts elsewhere. The human appropriation of net primary productivity (HANPP) embodied in the European Union's consumption is strongly dependent on the appropriation of biological productivity outside of Western Europe (Kastner et al., 2015), with increasing reliance on Latin America as a main supplier. Moreover, deforestation embodied in European Union consumption is almost entirely due to imports, as deforestation within the European Union is negligible (EEA, 2015b).

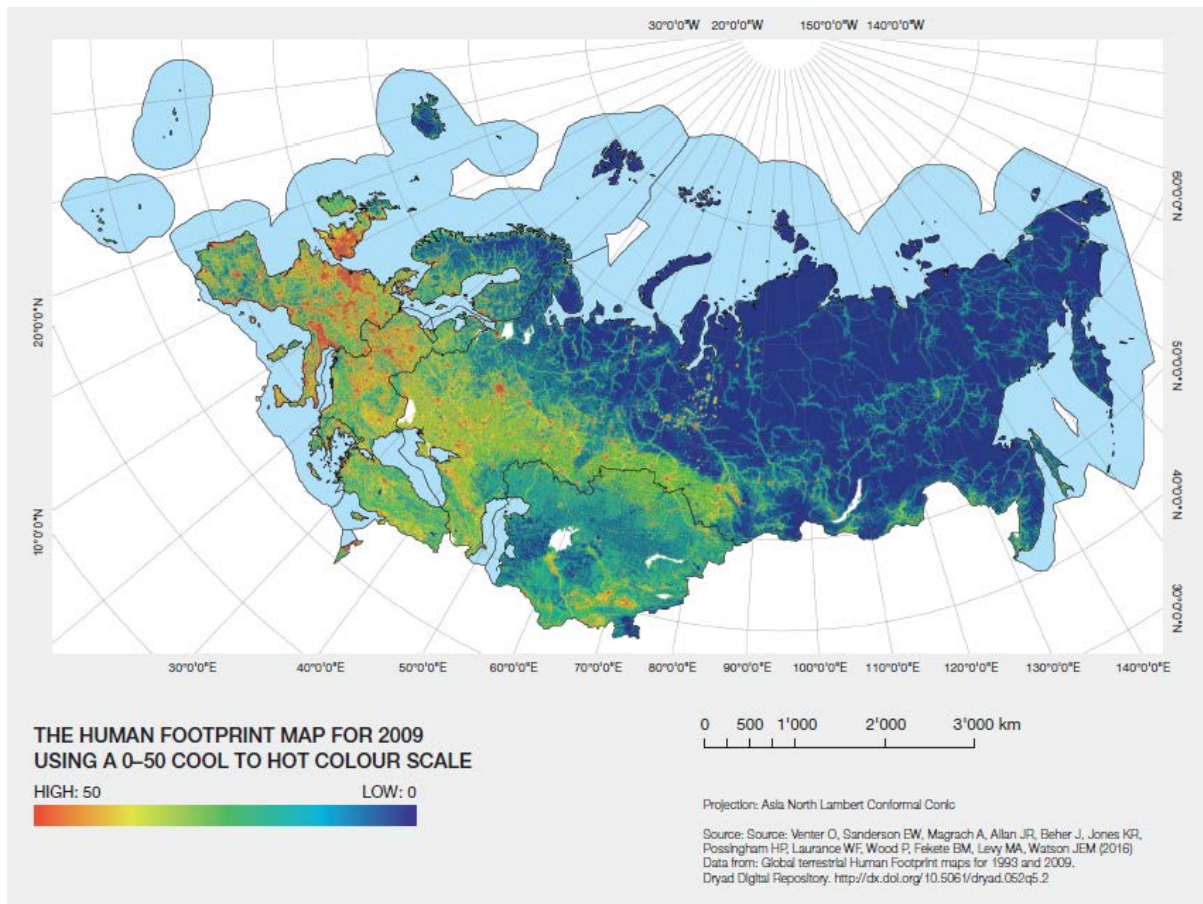


Figure 1.10: Human footprint in the Europe and Central Asia region (after Venter et al. (2016)) derived from the following indicators: 1) built environments, 2) population density, 3) electric infrastructure, 4) crop lands, 5) pasture lands, 6) roads, 7) railways, and 8) navigable waterways.

Central Europe

Central Europe is mostly a continental biogeographical region with segments of Alpine, Boreal, Pannonian, and Steppic landscapes, and also comprises Mediterranean and, in Turkey, subtropical ecosystems, and many subterranean cave habitats, especially in the Balkans. It includes a wide variety of landforms and geographical conditions. Low elevation moraine landscapes prevail around the Baltic coast (Estonia, Latvia, Lithuania, central and northern Poland), and are dissected by rivers, lakes and wetland systems following glacial landforms (Metzger, et al., 2012). Geographically, these areas belong to the eastern periphery of the Eastern European Plain. Farming dominates these landscapes, but one of Central Europe's largest primeval forests, Białowieża forest, is also located here, as well as large wetland areas in north-eastern Poland and Estonia. At the westernmost edge of the steppe zone, both semi-natural and natural grasslands occur, maintained by soil conditions, fire, aridity, and nowadays to a lesser extent herbivore pressure. These are some of the most diverse habitats of the region. Further south, lowland basins dominate the landscape separated by sub-alpine mountain ranges, including the Carpathian basin (with its sub-basins, the small and large Hungarian Plain and the Transsylvanian Plain), the Czech basin (drained by the Elbe, Vltava and Morava rivers) and the Wallachian Plain of the lower Danube. Mountain ranges and hills dissect the Balkan area (the main watercourses being the Danube and Sava rivers) which lacks extensive lowlands. The Anatolian Peninsula is surrounded by mountain ranges around the semi-arid Anatolian plateau. Although highly variable within small areas, climatic and edaphic conditions in Central Europe are favourable for agriculture, except in some water-deficient areas in the Anatolian plateau, and agriculture and forestry

are the most widespread land use types. Relatively large, but fragmented, forests exist mainly in boreal areas, while unmanaged forests are rare. Except for Białowieża forest in Poland, Romanian old-growth forests are unique in continental Europe. To safeguard the remnants of primeval forests, the world heritage list of the United Nations Educational, Scientific and Cultural Organization has recently been expanded (in July 2017), to include the Primeval Beech forests of the Carpathians, which stretch over Albania, Bulgaria, Croatia, Romania, Slovakia and Ukraine.

The political borders within Central Europe have been highly dynamic throughout history. This was caused by changes in political regimes from self-sustaining kingdoms to empires (Austria-Hungary, Prussia, the Ottoman Empire), two world wars in the 20th century, and finally by the dissolution of the Soviet Union in the late 1980s. Since the 1990s, most of Central Europe has been through important political and socio-economic transformations. This determined the nature of governance structures, affecting environmental protection and the management of natural resources, which currently remain of secondary importance to economic growth. Traditional practices and indigenous and local knowledge that are important for local nature conservation often survive in marginal cultural landscapes.

Although geopolitical transformations had different effects in different countries, the basic economic processes were similar as a consequence of the preparation of accession to the European Union (Bański, 2008). The semi-enclosed seas of the subregion have been influenced by eutrophication due to urbanization and fertilizer use, and the shore areas are increasingly under pressure from tourism. Invasive species are particularly a problem in the Black Sea and the Mediterranean Sea (Blenckner et al., 2015). Large patches of wetlands exist attached to floodplain river deltas and freshwater lake systems, but are influenced by water level regulation, infilling, pollution and drainage (Hein et al., 2016).

Central Europe is home to about 20% of the population of Europe and Central Asia on 6% of its land area, with population densities comparable to Western Europe. Many people live in rural areas in Central Europe, and there is only one megacity - Istanbul (out of 4 megacities located in Europe and Central Asia). However, with the exception of Albania, the added value of agriculture to the GDP of Central Europe is minor and economies are built on services and industry (The World Bank Group, 2016). Worldviews and value systems are highly diverse, partly as a consequence of this diverse history. Top-down determination of worldviews and values became stronger during the 20th century causing considerable change. During the Soviet era many community-level structures and informal regulations were deliberately dismantled. After 1989, a strong cultural revival was typical in many countries, together with an increase in national identity. Traditional values and lifestyles survive and are being adapted to the new socio-economic environment in thousands of semi-subsistence villages in marginal areas throughout Central Europe.

Central Europe is characterised by rapid economic and social development and urbanization in recent decades that increasingly resembles Western Europe together with relatively large areas of more intact nature in the form of cultural landscapes. The green corridors throughout such areas are of critical importance. These networks of landscape features dominated by near-natural vegetation enhance landscape connectivity, facilitating migration and dispersal of species. These existing resources raise the challenge of an alternative economic development pathway that can conserve natural capital while consumption patterns appear to continue to adjust to Western European norms. While local value systems are close to Western Europe, due to a similar long-term history, the ecological, economic and cultural heritage is different in many ways, influenced by divergent historical pathways in the 20th century. Environmental policy in Central Europe is strongly influenced by the

European Union since all Central European countries are either members of, or closely associated with, the European Union.

During the 20th century, many ecosystems were impaired by water and air pollution, such as acid rain, industrial waste, and production intensification. In Western Europe, protected areas cover on average 25% of the land surface, while in Central Europe the equivalent area is only 21% and in Eastern Europe 7% (The World Bank Group, 2016). However, biodiversity is often on average richer than in most parts of Western Europe. For example, some of the most species-rich grasslands in the world are found in Estonia and Romania (Wilson et al., 2012). There is increasing public support for, and interest in, nature conservation across Central European societies. Natural areas are seen as resources providing ecosystem services, supporting environmental resilience and facilitating adaptation to, and mitigation of, climate change (EEA, 2012). Climate change observations and projections indicate that Central Europe faces increasing risk of droughts and warm temperature extremes (EEA, 2015b) and, especially in the Mediterranean Sea, increasing sea temperatures and ocean acidification (Gambaiani et al., 2009).

Eastern Europe

Most of the IPBES subregion of Eastern Europe is geographically located in Asia: only Belarus, Moldova, Ukraine and the western part of Russia are completely within what is commonly known as Europe, while most of Russia is beyond the Urals, and Azerbaijan, Armenia and Georgia are beyond the Greater Caucasus, which are traditionally set as the geographic divides between Europe and Asia.

Most of this “European” part of Eastern Europe is occupied by the Eastern European Plain, spanning from the Black Sea and Caucasus to the Arctic Ocean, and from the easternmost European Union borders to the Urals. The Plain contains the basins of some of Europe’s longest rivers, such as the Volga, Dnepr and Pechora. Being a vast mountain-free space with an average elevation of only 170 m, the Plain shows a uniquely gradual and continuous change of climatic zones and biogeographic regions, from Arctic deserts and tundra to boreal taiga, and then to mixed and deciduous continental forests and forested steppes, steppes and semi-deserts of the steppic zone. Arctic deserts have negligible vegetation productivity due to the extreme cold and the short growing season, and are dominated by algae, mosses, lichens and only a few vascular plants (ca. 100 species), covering about half of the ground surface altogether. Tundra habitats also have permanently frozen subsoils and environmental conditions that do not allow for forest growth (temperature, wind, precipitation). Vegetation is composed of a grass and a moss layer with sparse bushes, inter-laced with open soil, including lichen and moss or alternatively shrub tundra. Such habitats have relatively low species diversity (totalling ca. 500 vascular plants). Only continental, and northern and middle steppic regions are dominated by croplands (with steppe soils often heavily overused and degraded), while the boreal taiga region is mostly forested, except the areas around major cities. The forests are mostly natural and semi-natural, and managed only towards the southern part of the taiga region and further to the south. The south-eastern segment of the steppic and semi-desert and desert strip (especially within the Caspian Depression) contains vast arid rangelands (Исаченко, 1985). Several old industrial areas (notably Donbass in Ukraine) are densely populated, while elsewhere, except the south-western part of the plain, population density drops to less than 10-15 people/km². The region contains the Moscow metropolitan area, one of the four in the region with more than 10 million inhabitants. Many areas in western Russia have been rapidly losing their rural population over several decades (Alekseev & Safronov, 2015). In addition, the Chernobyl nuclear accident of 1986 led to the relocation of hundreds of thousands of people in Belarus, Ukraine and Russia (Hostert, et al., 2011).

There are several mountain systems on the edge of the Eastern European Plain: the eastern (Ukrainian) Carpathians, Urals, Crimean Mountains, the Greater Caucasus and Khibiny. All of these,

especially the Greater Caucasus can be regarded as very important for biodiversity and, in general, their ecosystems are better preserved than the surrounding areas, except for some mining and industrial areas in the central and southern Urals, and the edges (especially in the south) of the Crimean Mountains and the Greater Caucasus, which are densely populated. The Greater Caucasus features a broad range of ecosystems, from dry steppes, semi-boreal forests, alpine meadows and glaciers to humid subtropical forests (Исаченко, 1985). Some of its peaks, including seven peaks over 5,000 m, are Europe's highest.

The geographically Asian part of Russia (Siberia and the Far East) stretches for over 5,000 km from the Urals to the Pacific coast, and for over 3,000 km from the Arctic Ocean to Mongolia and China. It consists of the flat and swampy (except the southern steppic part) Western Siberian Lowland, the hilly and sometimes low mountainous Central Siberian Plateau, the Southern Siberian (Altai, Sayany) and Transbaikalian Mountains limiting the lowlands and the plateau in the south, and the extremely complex topography of the almost entirely mountainous Russian Far East. Most of the area is covered by boreal taiga, except for tundra and Arctic deserts in the extreme north and in Arctic archipelagos, while in the south, the taiga changes to semi-steppes and steppes. There is an area of semi-deserts between the Sayany mountains and Mongolia. The mountains (except those located in high latitudes) are mostly forested and recognised as important global and regional biodiversity hotspots. Taiga forests are not managed sustainably. There, control and protection cannot prevent forest fires and illegal logging and the area of burnt forests is larger than the area of logging reported by the Russian Forest Agency (Minprirody of Russia, 2016). Most of the steppe and semi-steppe landscapes have been converted to croplands and pastures, except saline areas and some broken terrains. The Russian Far East is richer in biodiversity than Siberia, especially its south-eastern part, which is covered with deciduous and mixed monsoon forests (this also includes the southern part of the Kuril Islands) (Гвоздецкий & Михайлов, 1978). Siberia and the Far East are drained by some of Asia's largest rivers, such as Lena, Yenisei, Ob' and Amur; Lake Baikal located at the south-eastern edge of the Central Siberian Plateau is the world's largest (in terms of volume of water) and deepest (up to 1,642m) freshwater body and a unique habitat to many endemic species. Human population density is extremely low in most of Siberia and the Far East, and everywhere except the southern steppic edge and some industrial and mining areas, is below 1 person/km². In the areas north of the relatively inhabited strip, most settlements are in river valleys. The industrial areas are often heavily polluted. Climate change is an important threat to the nature of Siberia and the Far East, especially given that most of the region has permafrost, while the ecosystems in the Arctic Ocean are sensitive to sea ice dynamics.

The Transcaucasia region contains the flat and wet Kolkhida Depression open to the Black Sea, the dry Kura-Aras Depression open to the Caspian Sea, the Lesser Caucasus Highlands between and to the south of the Lowlands, and the Greater Caucasus in the north. The coastal lowland areas are home to the only humid and semi-humid subtropical forests of the subregion, with high levels of endemism and quite high diversity (several thousand vascular plant species). The Kolkhida Depression is densely populated (mostly by over 100 people per km²) and dominated by croplands, with only very small fragments of subtropical wetlands remaining by the seashore. The Kura-Aras Depression is located in the zones of subtropical steppes, subtropical forests and semi-deserts, and most of it is converted to croplands and pastures, except some saline and broken lands; the population density is sparser in general (50-100 people per km²) than in Kolkhida, although next to major cities it can be as high. The Lesser Caucasus is a system of relatively low mountain ridges, mostly deforested and heavily eroded, occupied by pastures and with high-density populations in the valleys. It is an important regional biodiversity hotspot.

The common historical legacy of Eastern Europe is closely tied to the history of the Soviet Union, which has led to a gradual and challenging political and socio-economic transition. During the Soviet era, many social and economic institutions, especially those related to self-organization, entrepreneurship and religion, were destroyed or severely damaged. This also had a strong and clearly visible impact on patterns of rural settlements. In Belarus and Ukraine, whose western parts only became Soviet in 1939, the pre-war border of the USSR can be traced even on topographic maps, where dense networks of small villages and farms suddenly change to patterns dominated by large villages with vast empty spaces surrounding them. This divider can also be found in many behavioural patterns and cultural preferences including attitudes towards nature and livelihoods. It is generally noted that more traditional ways have been preserved in the Caucasus, some other mountain systems (e.g. Carpathians) and the northern parts of Eastern Europe. The trend in recent decades has been a growing interest in traditional values combined with rapidly globalizing lifestyles and consumption. Environmental awareness is generally growing, but is still a somewhat low priority.

The core of the system of protected areas was established by the USSR, although it has significantly expanded since then, inspite of conservation programmes being underfunded in most countries. The countries of Eastern Europe maintain hierarchical political systems, limiting public participation in the development of nature conservation mechanisms and with different degrees of involvement of the public and of non-governmental organizations in the establishment and management of protected areas; corruption is also considered to be a serious concern in some countries, and can result in illegal deforestation, land-grabbing, soil degradation and environmental pollution (Newell & Simeone, 2014; Richardson, 2015). All Eastern European countries, except Belarus, are involved in local armed conflicts that have led to substantial biodiversity losses (Burns et al. 2017). Eastern European countries have well-integrated environmental legislation, initially based on common USSR legislation. More recently, some countries have started to harmonize their environmental legislation with European Union directives and best practices, but compliance standards are rather low in most instances (Ermolin & Svolkinas, 2016; Malets, 2015). All Eastern European countries report to the Convention on Biological Diversity.

Nevertheless, the emerging multilevel biodiversity governance arrangements, such as the European Diploma for Protected Areas or forest certification schemes, work towards more transparent and accountable nature conservation regimes (Otto et al., 2011).

Central Asia

The five countries constituting Central Asia were all former Soviet republics, located between the Caspian Sea and China. The subregion has a harsh continental climate, and is dominated by steppic landscapes in the north changing to deserts in central and southern parts. Its deserts have warm or cold climates with precipitation less than 250mm/year (according to the Köppen-Geiger classification, or 150mm according to the IPBES land degradation assessment), with specific soil types and vegetation (Asian Development Bank, 2010). They have moderate species richness, for example comprising a total of 1,000-1,500 recorded vascular plant species). Most of Central Asia consists of plains or hilly uplands, which are delimited by mountain systems on the eastern and southern peripheries. The main geographical subdivisions of Central Asia are central Kazakhstan (subdivided into the Turgay Plateau and Kazakh Uplands) and the vast desert plain to the south that contains numerous plateaus, uplands and lowlands. In the geographic literature, this plain is often divided into two: the region of northern deserts and the region of southern deserts (Гвоздецкий & Михайлов, 1978). Central Asia is limited in the east and south by large mountain systems with extensive glacier and nival ecosystems. Such habitats have low temperatures and a short growing season (< 10 days) (Körner et al., 2011). Central Asia also includes the southernmost parts of the Eastern Siberian

Lowlands, the Urals (Mugodzhar Hills), Altai and the Eastern European Plain. Croplands in Central Asia are irrigated everywhere except at their northern edge and in some mountainous areas and, therefore, most settlements and the highest density of rural population are found in river valleys and similar irrigated areas. The vast areas between these settlements are almost uninhabited and mostly used for animal husbandry (usually nomadic), often based on indigenous and local knowledge. All the rivers in the central and southern parts of the subregion belong to endorheic basins (closed basins or internal drainage systems), and water overuse due to irrigation has led to severe downstream water quantity and quality issues, the most famous being the dessication of the Aral Sea, which was one of the largest inland lakes of the world in terms of surface area.

The Caspian Depression geographically belongs to the Eastern European Plain and is a flat lowland (Гвоздецкий & Михайлов, 1978). Its southern part is dominated by rangelands with sandy and salty deserts, salt marshes and salty lakes, while in the central part and further towards the north the landscapes change to desert and then to dry steppes. Croplands are found only on the northern edge of the depression, while the rest is used for sheep husbandry, mostly nomadic. The south-east of the depression is an old oil production area with soil and water pollution widespread. The Eastern Siberian Lowland within Central Asia is a steppic landscape that changes to dry steppes in the south, often with salty soils, marshlands and numerous salty lakes towards the south-east (Исаченко, 1985). It is dominated by croplands, with rangelands mostly occurring in salty landscapes.

The Mugodzhar Hills and Central Kazakhstan are dominated by dry steppes in the north and semi-deserts towards the south. The steppes are mostly cultivated, while the semi-deserts are used for sheep husbandry. The Mugodzhar Hills reach 657m; the Turgay Plateau is a system of plateaus slightly elevated over surrounding areas (up to 310m); while the Kazakh Uplands is a hilly area with strongly eroded residual mountain ridges (the highest peak is 1,565m), thousands of small lakes, and relict pine forests on northern slopes (Гвоздецкий & Михайлов, 1978). A large area in the north-eastern segment of the Uplands (over 18,500 km²) was used from 1949 to 1991 as a test site for nuclear weapons, and is still heavily contaminated. Central Kazakhstan is limited in the east by the westernmost ranges of the Altai and the Saur and Tarbagatai Mountains. The core of Altai is in Russia, while peripheral parts are also found in China and Mongolia. The Altai Mountains are dominated by coniferous forests. Alpine and subalpine meadows are less common. The Kazakh part of Altai is an important mining area with large-scale non-ferrous metal production that causes heavy environmental pollution.

The region of the northern deserts is located in southern Kazakhstan, northern and western Uzbekistan, and northern Turkmenistan, and includes a small portion of Kyrgyzstan in the valley of the Chu River. It is characterised by low winter temperatures, with January averages from -4°C in the south to -16°C towards the north (Asian Development Bank, 2010). The most prominent landforms of the region of northern deserts are the Plateaus of Ustyurt (raising from 150 to 365m) and Mangyshlak (555m); the rest is a rather extensive plain with a few residual mountain ridges, gradually raising from about 5m under the cliff of Plateaus of Ustyurt to 300-500m in the east, next to the Dzungarian Gate, connecting the plain with the Dzungarian Depression in China. This plain is dominated by sandy deserts in the western (Kyzylkum, Aralain Karakum, Barsuki) and eastern parts (Saryesik-Atyrau), while the central part is mostly stony and clay desert (Betpak-Dala). The plain contains several large lakes, including the remnants of the Aral Sea, and the Lake of Balkhash (half of which is salty, while the other half is fresh water), and is crossed by a few major rivers with large deltas, such as the rivers of Syr Darya and Amu Darya that used to be tributaries of the Aral Sea, the Ili that is a tributary of the Balkhash, and the Chu disappearing into the desert. Due to intensive irrigation, the rivers' discharge is continuously dropping which, in addition to the loss of the Aral Sea, threatens the existence of the

Lake of Balkhash. Surface irrigation also leads to soil salinisation, especially in clay deserts, such as Betpak-Dala. Most of the area is rangeland, used for animal husbandry. Croplands such as cereal and cotton are found in river valleys and irrigated areas fed by the rivers. Remnants of riparian forests (also known as “tugai”) can be found in the deltas of the Amu Darya and the Ili, and along the along the Syr Darya. These have high productivity and moderate species diversity (ca. 600 vascular plants) with many endemics, and serve as habitats for many iconic mammal species (Milkov, 1977) (Sokolov & Syroyechkovskiy, 1990).

The region of southern deserts includes most of Turkmenistan (except the extreme north and the south-western mountain part), central Uzbekistan, and the southernmost part of Kazakhstan. January average temperatures are 0°C or higher, while July averages are the highest in the Europe and Central Asia region exceeding +32°C in southern Turkmenistan (Asian Development Bank, 2010). Most of the region is a rather monotonous plain gently raising from -28m at the shore of the Caspian Sea to 200-300m in the east. The prevailing landscape is sandy deserts (Karakum, southern Kyzylkum) with salty marshes and clay deserts occurring by the Caspian Sea (especially by the Bay of Garabogazköl) and in local depressions. The most important rivers are the Syr Darya, the Amu Darya, the Zeravshan and the Murghab (the latter two with deltas disappearing into deserts); all heavily utilised in large-scale irrigation projects. The most important project was the Karakum Canal, constructed in 1954-1988 to promote cotton production in Turkmenistan. It is 1,375km-long, and carries over 13km³ of water annually from the Amu Darya, which arguably led to the disappearance of the Aral Sea. Due to its high water losses the canal also causes soil salinization along its route. Deserted rangelands dominate the region of southern deserts and are mostly used for sheep and camel husbandry, often nomadic.

The mountain peripheries of Central Asia are often divided into three areas, which are distinctively different in terms of geomorphology and climatic characteristics (Гвоздецкий & Михайлов, 1978): (1) the Central Asian Mountains (Saur, Tarbagatai, Dzungarian Alatau, northern Tian Shan), (2) south-eastern Tian-Shan and Pamir, and (3) Kopet Dag. All of these areas are important for biodiversity. The Central Asian Mountains consist of high ranges (Dzungarian Alatau reaches 4,464m, and northern Tian Shan reaches 7,439 m), which usually stretch latitudinally. The mountains are dominated by steppes, shrubs and dry meadows, while lower ranges are covered by shrubs and arid woodlands. The foothills and intermountain depressions are mountain deserts, which are often irrigated and densely populated; the most important depressions (also known as “valleys”), such as Fergana and Gissar, and contain a large proportion of Central Asia’s population. The Central Asian Mountains include several large lakes, notably Issyk-Kul, which is a habitat for many endemic species. Primary wild walnut-fruit forests are a specific feature of the Central Asian Mountains, occurring on mountain slopes around 1,000 m above sea level wherever precipitation is sufficient (Shukurov, 2016; Shukurov et al., 2005). They are dominated by walnut (*Juglans regia*), maple, juniper and wild variants of many cultivated fruit trees, thus representing an extremely important genetic reserve. With about 300 species of vascular plants, these forests are not particularly diverse, but have a large number of tree and shrub species, with many endemics and rare species (Ashimov, 2014; Safarov et al., 2014; Shukurov, 2016). South-eastern Tian-Shan and Pamir is a complex junction of the Central Asian mountain ranges. Its highest peak in Central Asia is 7,495m. The prevailing landscapes are high-mountain plateaus, valleys and ridges covered with dry meadows and mountain steppes. There are many glaciers, including the Fedchenko Glacier that is the world’s longest outside of the polar regions. Most of Pamir is sparsely populated; the valleys are used for seasonal pastures. Kopet Dag is recognised as the northern extension of the Iranian Uplands. It is a relatively low mountain range reaching 2,940m and covered with shrubs and low woodlands, which are mostly used for sheep husbandry.

Central Asia experienced attempts at rapid industrialisation and socio-economic change during the Soviet era, followed by massive migration from the western parts of the USSR, while local ethnic communities maintained many traditional ways and practices, especially in the countryside, and remained almost unchanged in remote areas, such as the mountain periphery. The exceptions include northern Kazakhstan dominated by migrants from western parts of the USSR, and some large cities. After the dissolution of the Soviet Union in 1991, the significance of traditional cultural and religious views and practices grew considerably, although to varying extents across the region. Environmental disasters, such as the drying out of the Aral Sea and large scale soil salinisation, as well as conflicts over water resources, keep environmental awareness relatively high and well represented in policy agendas, although much oriented towards resource availability and quality of life.

When Central Asia was part of the Soviet Union, many large-scale irrigation and hydropower projects were launched that led to water management problems. With the end of the Soviet era these issues became transboundary in nature, but with Central Asian countries rebuilding their economies, the preservation of natural resources was often assigned a low priority. In the 21st century, the transition to a green economy and more resource-conscious agriculture was initiated in several Central Asian countries. Programmes for conserving agro-biodiversity, wetland habitats and CO₂ sequestration have been put in place, and indigenous and local knowledge continues to contribute to land management, especially in areas where semi-nomadic and transhumance livelihoods prevail. The natural contributions provided by these large steppe areas are important at the global level, especially for climate regulation, water regulation and soil formation. Many Central Asian States are interested in the transition to a green economy and have the natural capital to support this, but the prospect of rapid economic development based on the export of resources also has strong potential.

1.3.5 Relationships between Europe and Central Asia subregions

Transboundary connections within and beyond Europe and Central Asia are briefly introduced here, and are dealt with more extensively in Chapter 2. Europe and Central Asia has a number of transboundary issues that broadly fall into 3 categories: 1) transboundary governance systems, 2) transboundary nature and its contributions to people, and 3) links to other regions of the world. The European Union is economically the largest of the trans-boundary governance structures, and a major player in ecological protection in the region. However, other important transboundary governance structures exist, such as the European Free Trade Association (EFTA) of Iceland, Liechtenstein, Norway, and Switzerland, the Commonwealth of Independent States (CIS) of Russia, Ukraine, Belarus, Kazakhstan, Kyrgyzstan, Tajikistan, Armenia, Azerbaijan, Uzbekistan, Turkmenistan and Moldova, and the Eurasian Economic Union (EEU) of Belarus, Kazakhstan, Russia, Armenia and Kyrgyzstan. Although these associations are broadly based on economic criteria, they provide opportunities for cultural exchange and shared interests across a range of topics, potentially including the protection of natural capital.

A major transboundary issue for nature and its contributions to people concerns water as a resource and as a habitat, especially along major rivers, with the impact of dams, hydroelectric plants and water abstraction for irrigation from lakes, rivers and inland seas. Effects can be far-reaching from source to sea inlet and often bridge several subregions. Furthermore, air pollution can have widespread geographic impacts on habitat quality, especially nitrogenous compounds. Resources, products, pollution and waste are also transported across the boundaries within Europe and Central Asia, which impacts on ecosystems in multiple ways, including eutrophication and invasive species. However, green corridors (mountain ranges, river floodplains, the former Iron Curtain) provide a more positive benefit of transboundary interactions across Europe and Central Asia.

1.3.6 Global connections and issues

Europe and Central Asia has many links and teleconnections with the rest of the world, notably through global trade and the transport of goods (Kastner et al., 2015). Transport supports the movement of invasive species that impact directly on ecosystem quality within the region (Hulme, 2009). The import of food and other goods has the effect of displacing the environmental pressures exerted by Europe and Central Asia's regional consumption to other parts of the world (Cuypers et al., 2013), while Europe and Central Asia is dependent on these imported goods. Moreover, there is some evidence to suggest that Western Europe has been responsible for overfishing in waters beyond its jurisdiction, e.g. (Akiba, 1997). Cultural links with regions outside of Europe and Central Asia are important in transforming human livelihoods, consumption patterns, value systems and attitudes towards nature, which also affect local nature and its contributions to people. China is an important emerging power that has an influence from outside the Europe and Central Asia region (Tracy et al., 2017). China-led political, security and economic initiatives, such as the Silk Road Economic Belt or the Shanghai Cooperation Organization are increasingly visible in the region, in particular in Eastern Europe, and even more so in Central Asia. The implications for nature are not entirely clear yet, but impacts may arise from the further growth of international trade, and possibly with large-scale infrastructural developments in regions bordering China (Tracy et al., 2017).

1.4 The global and regional policy context

1.4.1 The Aichi Biodiversity Targets and the Sustainable Development Goals

Aichi Biodiversity Targets. In 2010, the Parties to the Convention on Biological Diversity adopted the Strategic Plan for Biodiversity 2011-2020, encompassing a long-term vision and a shorter-term mission (see **Box 1.2**). The 20 Aichi Biodiversity Targets, divided among five Strategic Goals, are part of the Strategic Plan and an essential tool for its implementation (CBD, 2010b). To determine whether progress is being made toward halting biodiversity loss and ensuring that ecosystems are resilient and provide essential services for good quality of life, requires an assessment of current states, and an understanding of past and future trends. Tracking progress towards the Aichi Biodiversity Targets allows an evaluation of the progress towards the accomplishment of both the vision and mission of the Strategic Plan.

Box 1.2: The vision and mission of Strategic Plan for Biodiversity 2011-2020

"Living in harmony with nature"- The vision of the Strategic Plan

"By 2050, biodiversity is valued, conserved, restored and wisely used, maintaining ecosystem services, sustaining a healthy planet and delivering benefits essential for all people."

The mission of Strategic Plan

"take effective and urgent action to halt the loss of biodiversity in order to ensure that by 2020 ecosystems are resilient and continue to provide essential services, thereby securing the planet's variety of life, and contributing to human well-being, and poverty eradication. To ensure this, pressures on biodiversity are reduced, ecosystems are restored, biological resources are sustainably used and benefits arising out of utilization of genetic resources are shared in a fair and equitable manner; adequate financial resources are provided, capacities are enhanced, biodiversity issues and values mainstreamed, appropriate policies are effectively implemented, and decision-making is based on sound science and the precautionary approach."

(Convention on Biological Diversity 2010)

End of Box 1.2

Sustainable Development Goals. The Sustainable Development Goals (SDGs) (United Nations, 2015) form the key component of the United Nations' 2030 Agenda for Sustainable Development, and are a re-affirmation of the world's commitment to move towards sustainable development. There are 17 Sustainable Development Goals with 169 targets covering a wide-range of areas, from ending poverty to empowering women and protecting the environment. The Sustainable Development Goals (together with the Aichi Biodiversity Targets) provide a global framework within which to tackle the biodiversity crisis. Goals 14 and 15 address biodiversity and ecosystems (nature) explicitly. However, the broader importance of nature to quality of life makes the Europe and Central Asia assessment relevant for several Sustainable Development Goals. **Table 1.5** maps the Europe and Central Asia questions onto the Goals.

The fifth national reports to the Convention on Biological Diversity provided an important source of information for the mid-term review of progress towards the implementation of the Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets. The fifth national reports have also contributed to the development of the fourth edition of the Global Biodiversity Outlook (CBD, 2014).

1.4.2 The relationship between the Europe and Central Asia policy questions, the Aichi Biodiversity Targets, the Sustainable Development Goals, and other biodiversity policies

Since the formulation of the general questions, and those specific to Europe and Central Asia, responded to requests by Governments, multilateral environmental agreements and other stakeholders, they are relevant to policy agendas encapsulated within the Strategic Plan for Biodiversity 2011-2020 and the 2030 Sustainable Development Agenda. **Table 1.5** maps the Europe and Central Asia policy questions onto the Aichi Biodiversity Targets and the Sustainable Development Goals. The following sections describe how different parts of the Europe and Central Asia region contribute to achieving these policy goals.

Table 1.5: How the Europe and Central Asia policy questions relate to the Aichi Biodiversity Targets and Sustainable Development Goals (see Section 1.1.1 for an overview of the Europe and Central Asia questions).

Policy-relevant questions	Aichi Biodiversity Targets	Sustainable Development Goals
1. Importance of nature to humans	1, 2, 3, 4, 14, 15, 16	1, 2, 3, 6, 7, 8, 9, 11, 13, 14, 15
2. Current change of nature (ecosystems and biodiversity) and its consequences	5, 6, 7, 11, 12, 13, 14, 15, 18, 19	3, 6, 13, 14, 15
3. Causes of this change	3, 4, 8, 9, 10	12, 13, 14, 15
4. Opportunities for policies and interventions	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17	1, 2, 3, 6, 7, 8, 12, 13, 14, 15, 16, 17
5. Identification of knowledge gaps	18, 19	6, 12, 13, 14, 15

Policy-relevant questions	Aichi Biodiversity Targets	Sustainable Development Goals
6. Opportunities to apply investment, regulation and management instruments for protection of important ecosystems and management of their contribution to people and good quality of life	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20	1, 2, 3, 6, 7, 8, 9, 11, 12, 14, 15, 17
7. Impacts of production, consumption and economic development on nature and nature's contributions, including effects in other regions	2, 4, 6, 7, 8, 9, 10	10, 12, 13, 14, 15
8. How policy sectors and instruments can encourage opportunities for good quality of life related to biodiversity and ecosystems (nature)	3, 4, 6, 8, 9, 10, 13, 14	2, 3, 6, 7, 8, 9, 11, 12, 13, 14, 15

1299

1300 **European Union Countries.** The European Union Biodiversity Strategy 2020 emerged from the Birds
 1301 and Habitats Directive, as the cornerstone of European Union biodiversity protection policy (adopted
 1302 in May 2011). The aim of the Biodiversity Strategy 2020 is to halt biodiversity loss in the European
 1303 Union, restoring ecosystems where possible, and stepping up efforts to avert global biodiversity loss.
 1304 The European Union Biodiversity Strategy to 2020 sets six targets addressing the main pressures on
 1305 nature and ecosystem services in the European Union and beyond (Birdlife Europe and Central Asia,
 1306 2015; European Commission, 2011). As such, the European Union has laid down a commitment to
 1307 various biodiversity-related conventions and the Aichi Biodiversity Targets. **Table 1.6** shows the links
 1308 between the European Union Strategy targets and the Aichi Biodiversity Targets, which integrate the
 1309 concept of ecosystem services as an approach to ecosystem conservation and restoration. For
 1310 example, at the European Union level, policies already integrate the ecosystem services approach into
 1311 member States' economy and planning, for example in the new rural development policy for 2014-
 1312 2020, the European Union's regional and cohesion policy, and the blueprint to safeguard the future of
 1313 its waters by 2015 (Maes et al., 2012).

1314 **Table 1.6: Comparison of the targets of the European Union Biodiversity Strategy to 2020 and the**
 1315 **Aichi Biodiversity Targets based on (BISE, 2015; CBD, 2015).**

European Union Biodiversity Targets	Aichi Biodiversity Targets*
Target 1: Fully implement the Birds and Habitats Directives	1, 11, 12
Target 2: Maintain and restore ecosystems and their services	15, 14, 8, 10
Target 3: Increase the contribution of agriculture and forestry to maintaining and enhancing biodiversity	7, 5, 13
Target 4: Ensure the sustainable use of fisheries resources	6, 7, 10
Target 5: Help combat Invasive Alien Species	5
Target 6: Help avert global biodiversity loss	2, 3, 16, 17, 20

1316 *The three missing Aichi Biodiversity Targets, particularly Target 4 (partnership for biodiversity), and
 1317 Targets 18 and 19 (building on the biodiversity knowledge base) are cross-cutting issues.

1318 **Non-European Union countries.** Countries outside the European Union contribute to the
 1319 implementation of the Aichi Biodiversity Targets through national strategies, plans or programmes (in

line with Article 6 of the Convention on Biological Diversity). Currently, almost all Parties to the Convention (189 out of 196) and all countries in Europe and Central Asia with the exception of Cyprus, Monaco and San Marino, have developed national biodiversity strategies and action plans (NBSAPs). NBSAPs are instruments for the effective implementation of the Convention at the national level, with the expectation of leading to the successful fulfilment of the Convention. Parties have different levels of NBSAP completion. Only 10 Europe and Central Asia countries completed a revision of the NBSAPs prior to the 10th Conference of the Parties to the Convention on Biological Diversity, when the Aichi Biodiversity Targets were adopted. By August 2017, most of the Europe and Central Asia countries had a revised version of the NBSAP, but for the others, revisions are still underway (**Table 1.7**).

Countries of Europe and Central Asia are signatory to the Convention on Biological Diversity and so, have committed to change their biodiversity strategy to meet the Aichi Biodiversity Targets. The Europe and Central Asia key questions reflect this engagement in responding to current needs and requests by diverse stakeholders from governments to local communities.

Table 1.7: Status of the development of National Biodiversity Strategies and Action Plans of countries in Europe and Central Asia (source: www.cbd.int/doc/nbsap/nbsap-status.doc) as at July 2017.

Status of NBSAPs Development		Pre-COP-10	Post COP-10
Central Asia	Kazakhstan	x	
	Kyrgyzstan		x
	Tajikistan		x
	Turkmenistan	x	
	Uzbekistan	x	
Central Europe	Albania		x
	Bosnia and Herzegovina		X
	Bulgaria	x	
	Croatia		X
	Cyprus	NBSAP not submitted yet	
	Czech Republic		x
	Estonia		x
	Hungary		x
	Latvia		x
	Lithuania		x
	Montenegro		x
	Poland		x
	Romania		x
	Serbia		x
	Slovakia		x

Status of NBSAPs Development		Pre-COP-10	Post COP-10
	Slovenia	Strategy only	
	TFYR Macedonia	x	
	Turkey	x	
Eastern Europe	Armenia		x
	Azerbaijan		x
	Belarus		x
	Georgia		x
	Moldova		x
	Russian Federation		x
	Ukraine		x
Western Europe	Andorra		x
	Austria		x
	Belgium		x
	Denmark		x
	Finland		x
	France		x
	Germany		x
	Greece		x
	Iceland	Partial revision planned	
	Ireland		x
	Israel	x	
	Italy		x
	Liechtenstein		x
	Luxembourg		x
	Malta		x
	Monaco	NBSAP not submitted yet	
	Netherlands		x
	Norway		x
	Portugal	x	
	San Marino	NBSAP not submitted yet	
	Spain		x
	Sweden		x

Status of NBSAPs Development		Pre-COP-10	Post COP-10
	Switzerland		x
	UK		x

1.4.3 Other environmental and non-environmental policies and governance

European Union countries. In addition to the European Union Biodiversity Strategy 2020, there are a number of other sectoral policies within the European Union that affect biodiversity and ecosystems. The Water Framework Directive aims to ensure the “good ecological status” of European water bodies (European Union, 2008b). The Common Agricultural Policy (CAP) has been expanded from its food production focus to consider the broader implications of farm management for the environment, through a range of agri-environmental schemes targeting ecological infrastructure, e.g. (Batáry et al., 2015). The Common Agricultural Policy also supports rural development and the continuation of traditional agricultural practices of high nature value (EEA, 2015a). At the national and local level, European Union countries have implemented a number of land use planning policies to support green space (Kabisch et al., 2016), and to use the ecosystem services concept for improved nature conservation. There are also many listed conservation areas, implemented through national policy or as part of the European Union Natura2000 network of protected areas (European Commission, 2008).

The Common Fisheries Policy has become increasingly concerned with the management of fish stocks, although more action is needed to ensure the sustainability of all European Union fisheries. The European Union has developed Sea Basin Management Plans for the Mediterranean (Adriatic and Ionian Seas), the Black Sea, the North Sea, the Atlantic Ocean and the Arctic Ocean (European Commission, 2017b). It also implemented the Marine Strategy Framework Directive (MSFD) in 2008 (European Union, 2008a), a Directive for maritime spatial planning (European Union, 2014), and set out a Blue Growth Agenda (European Commission, 2015a).

Non-European Union countries. Most of the non-European Union countries of Europe and Central Asia are either involved in European Union- led initiatives, such as the European Environment Agency (EEA, n.d.), or European Union association agreements (all the non-European Union Western and Central European countries except for Switzerland, Georgia, Moldova and Ukraine), non-European Union organizations such as The European Free Trade Association (EFTA) (“European Free Trade Association,” n.d.), or in post-USSR, organizations led by Russia, such as the Commonwealth of Independent States (CIS) (“Commonwealth of Independent States,” n.d.) or the Eurasian Economic Union (EEU) (“Eurasian Economic Union,” n.d.). The countries involved in European Union-related initiatives are converging their biodiversity governance frameworks with that of the European Union. Post-USSR initiatives do not promote policies or institutions with direct implications for nature. Essentially, they are trade and customs agreements, although with ambitions of expanding to other sectors. The indirect impacts include, for example, the orientation of the agricultural sectors of the Commonwealth of Independent States and Eurasian Economic Union countries towards exports to the Russian market.

Most of the countries in the region have signed and ratified all the major multilateral environmental agreements dealing with nature and related trade and production issues. Private governance arrangements play an increasing role in national and international biodiversity governance regimes. A prime example is forest and fisheries certification, such as those by the Forest Stewardship Council and the Marine Stewardship Council. Although their fit to purpose and role in protecting species and habitats is heavily criticised, there is a consensus that the overall impact is positive (Elbakidze et al.

2011). In the case of the Forest Stewardship Council, this is often observed in countries with top-down governance systems (Niedziałkowski & Shkaruba, 2017).

1.5 Methods and approaches used in the assessment

1.5.1 The assessment procedure

The Regional Assessment for Europe and Central Asia synthesizes knowledge from the scientific literature and grey literature and captures indigenous and local knowledge. The assessment operates at the border of scientific *terra incognita*, dealing with large knowledge gaps, potential scientific disagreement and multiple evidence types. Interactions between humans and the natural environment are complex. To allow decision-makers to make informed decisions, experts need to communicate not only the findings in which they have a high level of confidence, but also those requiring further investigation. Confidence refers to the extent to which experts are assured of their findings. Low confidence describes incomplete knowledge and preventing a full explanation of an outcome or a reliable prediction of a future outcome; whereas high confidence conveys extensive knowledge and the ability to explain an outcome or predict a future outcome with much greater certainty. The Regional Assessment for Europe and Central Asia communicates confidence through the use of uncertainty statements (Seppelt et al., 2012), qualitative self-assessment (Crossman et al., 2013) and standardized confidence reporting (Jacobs et al., 2015). By following a common approach to applying confidence language within an assessment, authors are able to increase consistency and transparency.

For every key finding in the assessment report, the supporting evidence and the level of scientific agreement was evaluated and qualified with confidence statements, including validation and evaluation by holders of indigenous and local knowledge (see 1.5.4). Confidence statements for qualitative evidence were applied using a four-box model (see **Figure 1.11**). For any of these statements, a reference is included from the key finding to the section in the main assessment report, where the expert team treated the corresponding issue.



Figure 1.11: The four-box model for the qualitative communication of confidence. Confidence increases towards the top-right corner as suggested by the increasing strength of shading (Source: modified from Moss & Schneider (2000) in IPBES (2016)).

1.5.2 The approach to values used in the Regional Assessment for Europe and Central Asia

Valuation is central to assessments of nature. In this section, we explain how IPBES, and specifically the Regional Assessment for Europe and Central Asia, deals with valuation, which is essential to fully understand its findings. The design of governance, institutions and policies rarely takes account of the diverse values of nature. Valuation, if carried out in a way that is open to diverse perspectives, is a significant resource for a range of decision-makers, including governments, civil society organizations, and indigenous people and local communities. Therefore, value diversity is fully embodied within the IPBES conceptual framework. The Regional Assessment for Europe and Central Asia recognises culturally different worldviews, visions and approaches to achieving good quality of life, following the assessment guidelines on valuation (IPBES/4/INF/13: Preliminary guide regarding diverse conceptualization of multiple values of nature and its benefits, including biodiversity and ecosystem functions and services (deliverable 3 (d))).

IPBES considers three main value dimensions: (1) values directly linked to nature itself (including biodiversity and ecosystem structure and functioning); (2) values derived from nature's contributions

to people (including ecosystem services); and (3) values more directly linked to good quality of life (see **Table 1.8**). For each value dimension, the Europe and Central Asia assessment applied specific assessment methods. Basic understanding of the valuation methods used is important since these strongly influence the outcomes of each valuation (IPBES/4/INF/13: Preliminary guide regarding diverse conceptualization of multiple values of nature and its benefits, including biodiversity and ecosystem functions and services (deliverable 3 (d))).

In each of the three main value dimensions, different foci and targets of valuation were distinguished as they relate to different policy arenas and societal decision-making. For example, concern for *individual living beings* is expressed by animal welfare movements and policies, whereas concerns for *genetic diversity* are expressed in the Cartagena Protocol to the Convention on Biological Diversity. As there is overlap between different foci and their significance varies in different contexts, **Table 1.8** - rather than being a rigid classification - is a tool to structure research and the analysis of diverse values across different worldviews. In the detailed value targets, differences may occur between chapters, but these are mostly minor and do not affect findings concerning the value foci or dimensions.

Table 1.8: The diverse values addressed in the Europe and Central Asia assessment, based on the IPBES/4/INF/13: Preliminary guide regarding diverse conceptualization of multiple values of nature and its benefits, including biodiversity and ecosystem functions and services (deliverable 3 (d)) and accommodated following the wording of “nature’s contributions to people” for the purposes of Europe and Central Asia.

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Value Dimension	Value Type	Value Focus*		IPBES-Valuation Targets	further examples and clarifications
NATURE	Non-anthropocentric	N1	Individual organisms	Individual organisms	Living beings (biocentrism), sentient beings (animal welfare/rights)...
		N2	Biophysical assemblages	Biophysical assemblages	Populations, communities, ecosystems, biomes, the biosphere, Gaia, Pachamama, Mother Earth...
		N3	Biophysical processes	Biophysical processes	Evolution, ecosystem functions and processes, ecological resilience ...
		N4	Biodiversity**	Biodiversity	Genetic, functional, taxonomic and phylogenetic diversity, uniqueness, vulnerability...
NATURE'S CONTRIBUTIONS TO PEOPLE***	Anthropocentric- instrumental	C1	Options for NCP	18 Maintenance of options	
		C2	Regulation NCP	1 Habitat creation and maintenance	
				2 Pollination and dispersal of seeds and other propagules	
				3 Regulation of air quality	
				4 Regulation of climate	
				5 Regulation of ocean acidification	
				6 Regulation of freshwater quantity, flow and timing	
				7 Regulation of freshwater and coastal water quality	
				8 Formation, protection and decontamination of soils and sediments	
				9 Regulation of hazards and extreme events	
				10 Regulation of organisms detrimental to humans	
		C3	Material NCP	11 Energy	
				12 Food and feed	
				13 Materials	
				14 Medicinal, biochemical and genetic resources	
		C4	Non-material NCP	15 Learning and inspiration	
				16 Physical and psychological experiences	
17 Supporting identities					
GOOD QUALITY OF LIFE	Anthropocentric- Relational	Q1	cultural	Living well in harmony with nature	Stewardship, relationships and interactions between people and nature inherently entwined as systems of life, as also indicated by time spent for managing ecosystems, conservation activities, contemplation of nature...
				Identity and Autonomy	Sense of place, sense of community, historical values, agency, self-determination...
				Spirituality and Religions	Sacred sites, totemic beings, spiritual well-being...
				Art and Cultural heritage	Inspiration, artistic creation...
		Q2	societal	Sustainability and Resilience	Social-ecological resilience, social, economic and ecological sustainability...
				Diversity and Options	Biocultural diversity, diversity of current and future options ...
				Governance and Justice	Environmental justice, intra-generational equity, inter-generational equity...
		Q3	individual	Health and Wellbeing	Physical, mental, holistic health, biophilia...
				Education and Knowledge	Inspiration, education, experience, learning space...
				Good social relations	Community cohesion, social resilience, conviviality...
		Security and Livelihoods	Physical security, political stability, food and water security, energy security, livelihood security...		
*: The categorisation in the "value focus" column strictly serves as an aid for balanced aggregation and depiction of the diverse value dimensions, rather than mutually exclusive categories					
**: In the ECA assessment, the term " biodiversity " is used in different senses, from its scientific sense of biological diversity up till its more encompassing sense of the natural environment in general (see also Mace et al 2012)					
***: In the ECA assessment, both terms " nature contributions to people " and " ecosystem services " are used. The latter is used where referring to literature dealing with specific ecosystem services, while "nature contributions to people" is applied to convey statements referring to the broader category of anthropocentric values (which includes ecosystem services).					

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The following provides definitions applied in the Regional Assessment for Europe and Central Asia for the main value components. The definitions are based on the IPBES valuation guidance documents that are slightly adapted to the Europe and Central Asia context where needed.

Nature: In this assessment, the concept of “nature” refers to nature at large, encompassing a continuum from nature as an autonomous functioning and evolving system to nature involving domesticated plants and animals. Within the context of science, it includes categories such as biodiversity⁵, ecosystems, ecosystem functioning, evolution, the biosphere, humankind’s shared evolutionary heritage, and biocultural diversity. Within the context of other knowledge systems, nature also includes different beliefs and concepts held around the world by indigenous peoples and local communities, such as “Mother Earth” and “systems of life” (Díaz et al., 2015).

Non-anthropocentric values. These include the values that people attribute to living beings, species, ecosystems or regions that are not centred exclusively on humans and contributions to good quality of human life. Some of these values can be assessed using quantitative measures of biological diversity and ecological integrity that involve studies on biodiversity, individual organisms, biophysical assemblages and ecological processes at different levels.

- **Intrinsic values** are independent of any human experience or evaluation. Since intrinsic value can be recognized, but not quantified, by humans it is not the target of any valuation process (Pascual et al., 2017) (see also Batavia & Nelson (2017)). However, intrinsic values are one of the main motivations for nature conservation and for conducting this assessment.

Anthropocentric values. These are values centred on humans. An assessment of anthropocentric values must consider how they relate to the current state and potential changes in nature, nature’s contributions to people, and good quality of life. The two main types of anthropocentric values considered in IPBES are instrumental and relational values:

- **Instrumental values** refer to the value attributed to something as a means to achieve a particular end for humans, and in IPBES these are referred to as nature’s contributions to people (see below).
- **Relational values** are the positive values assigned to “desirable relationships”, such as those among people and between people and nature (Díaz et al., 2015). Relational values refer to both desirable human-human interactions and human-nature interactions. “Living in harmony with nature”, “living-well in balance and harmony with Mother Earth” and “human well-being” are examples of different perspectives on what in the IPBES context is referred to as good quality of life.

Nature’s contributions to people. Defined by Pascual et al. (2017) as “all the positive contributions, or benefits, and occasionally negative contributions, losses or detriments, that people obtain from nature. It resonates with the original use of the term ecosystem services⁶ in the Millenium Ecosystem Assessment (2005), and goes further by explicitly embracing concepts associated with other

⁵ In the Regional Assessment for Europe and Central Asia, the term “biodiversity” is used in different senses, from its scientific sense of biological diversity to its more encompassing sense of the natural environment in general and the concept of intrinsic value (see also Mace et al. (2012)).

⁶ The Regional Assessment for Europe and Central Asia uses both the terms “nature’s contributions to people” and “ecosystem services”. The latter is used when referring to literature dealing with specific ecosystem services, while “nature’s contributions to people” is applied to convey statements referring to the broader category of anthropocentric values (which include ecosystem services).

worldviews on human–nature relations and knowledge systems (e.g. “nature’s gifts” in many indigenous cultures) (Díaz et al., 2015)”. They can be assessed in many different ways, including economic, social and biophysical valuation methods. Each of these methods elicits different values and, so, requires a broad set of approaches (Boeraeve et al., 2014; Jacobs et al., 2016).

Good quality of life. The achievement of a fulfilled human life, the criteria for which may vary greatly across different societies and groups within societies. It is a context-dependent state of individuals and human groups, comprising aspects such as access to food, water, energy and livelihood security, and also health, good social relationships and equity, security, cultural identity, and freedom of choice and action (Díaz et al., 2015). These values are assessed using various methods. A valuation that looks at the social-ecological system as a whole is essential for fully understanding relational values. Such valuation combines data from, for example, narratives, preference assessments, participatory geographical analyses, historical studies and biophysical models. First-hand information from individuals holding relational values is essential.

Integrated valuation. Some valuation methods are appropriate at eliciting a wide range of values (e.g. cultural and social methods) while others are limited to specific value types (e.g. monetary valuation) (Jacobs et al., 2016). Values are not necessarily independent of one another and can co-exist. Human decisions are ideally made by weighing and summarizing different values that are highly dependent on socio-economic, biophysical and governance contexts (Gómez-Baggethun et al. 2014). Most policy decisions *de facto* include diverse values implicitly and are rarely based on economic, ecological or social impacts alone. Integrated valuation has been increasingly developed as a methodology or practice to achieve a more transparent approach in combining diverse values (Dendoncker et al., 2014; Jacobs et al., 2016). Integrated valuation was therefore put forward in the IPBES guidelines to achieve fair, reliable and policy relevant valuation (IPBES/4/INF/13: Preliminary guide regarding diverse conceptualization of multiple values of nature and its benefits, including biodiversity and ecosystem functions and services (deliverable 3 (d))).

IPBES includes integrated valuation directly within the assessment process. In the Europe and Central Asia assessment, integrated valuation was realized through several initiatives supported by a technical support unit established to address these issues. A workshop of valuation experts, the values liaison group for the Regional Assessment for Europe and Central Asia, provided feedback, concrete suggestions and support to the assessment authors, facilitated by the technical support unit for the assessment and the technical support unit on values.

1.5.3 Overview of methods and approaches used in the Regional Assessment for Europe and Central Asia

Each chapter of the Regional Assessment for Europe and Central Asia implemented a comprehensive literature review for a wide range of information sources, from primary information (map archives, databases) to peer-reviewed, academic literature as well as grey literature and knowledge from stakeholders, and indigenous peoples and local communities. The literature reviews adopted a systematic approach to evaluate the large body of information using specific key word searches in English, Russian and Ukrainian. The analysis also used supplementary sources of information, including indicators of relevance to the Convention on Biological Diversity, to the Aichi Biodiversity Targets, to the Sustainable Development Goals, and to regional biodiversity targets (e.g. the IUCN Red List

species⁷, UNstats⁸, Sustainable Development Goal indicators⁹, European Environment Agency indicators¹⁰). The literature reviews formed the basis of expert judgements by the author team including the attribution of confidence statements. Chapter 5 developed scenario archetypes to summarise plausible and consistent future developments for Europe and Central Asia. The archetypes synthesize impacts and identify the key sustainability issues facing policy and society across a wide range of scenarios found in the literature.

The assessment followed common guidelines to ensure consistency across chapters. This included the conceptual framework (see Section 1.1.5) introduced in the IPBES guide to assessments (IPBES/4/INF/9: Guide on the production and integration of assessments from and across all scales (deliverable 2 (a))), a glossary specific to the Europe and Central Asia assessment, a list of indicators (IPBES, 2017), a classification of the units of analysis (see **Table 1.3**), a typology of nature's contributions to people (Pascual et al., 2017) and the confidence statements (see Section 1.5.1).

1.5.4 Consideration of indigenous and local knowledge (ILK)

Indigenous and local knowledge (ILK) systems in IPBES are dynamic bodies of integrated, holistic, social-ecological knowledge, and practices and beliefs about the relationships between living beings, including humans, and their environment. Indigenous and local knowledge is highly diverse, and produced in a collective manner at the interface between the diversity of ecosystems and human cultural systems. It is continuously evolving through the interaction of experiences and different types of knowledge (written, oral, tacit, practical, and scientific) among indigenous peoples and local communities.

Taking indigenous and local knowledge into account in nature-related assessments improves both the social robustness and the accuracy of the outcomes, i.e. outcomes are closer to the studied context (Cowling et al. 2008; Donovan et al. 2009; Flint et al. 2013). This follows from the recognition that many of the remaining biodiversity-rich regions of the world are also homelands to indigenous peoples and local communities (cf. Convention on Biological Diversity). Indigenous and local knowledge holders can represent complementary sources of knowledge, often working at different scales of time and space, addressing different kinds of issues, and informing areas that science has not investigated see e.g. Kalkanbekov & Samakov (2016). As indigenous peoples retain within their knowledge systems an inter-generational memory of fluctuations, trends and exceptional events in relation to the local environment, they can contribute importantly to understanding processes of change, whether these are long-term, global transformation processes or circumscribed local events.

Indigenous and local knowledge is partly available in the published scientific literature, which reports observations from indigenous peoples and local communities about ecosystem characteristics and trends, and drivers of change. However, the integration of indigenous and local knowledge into mainstream science often implies the application of a validation process, which may not be an appropriate way of treating knowledge holders (Agrawal, 2002; Danielsen et al., 2014; Huntington et al., 2002; Kalkanbekov & Samakov, 2016; Nadasdy, 1999). An increasing amount of scientific literature now seeks to produce and co-produce knowledge relevant to local conditions and actors by integrating the complex contextual and socio-ecological knowledge of indigenous peoples and local communities,

⁷ <http://www.iucnredlist.org/>

⁸ <https://unstats.un.org/unsd/default.htm>

⁹ <https://mdgs.un.org/unsd/mdg/Default.aspx>

¹⁰ http://www.eea.europa.eu/data-and-maps/indicators#c5=&c0=10&b_start=0

e.g. (Fagerholm et al. 2012; Fontaine et al. 2014; Sillitoe 2006). IPBES seeks to progress this approach by bringing indigenous and local knowledge into IPBES assessments from the outset. IPBES developed guidance for the integration of indigenous and local knowledge into its assessments that respects not only the diversity and value of this knowledge, but also the rights of indigenous and local communities to share the benefits of knowledge gained from the assessments. IPBES integrates indigenous and local knowledge into its assessments through the appointment of experts with expertise in the subject. In the Regional Assessment for Europe and Central Asia, indigenous and local knowledge was integrated through several initiatives supported by a task force on indigenous and local knowledge. A workshop of indigenous and local knowledge holders and experts provided relevant case studies and white and grey literature to the assessment authors. It also introduced the assessment to indigenous and local knowledge holders at an early stage. Subsequently, these knowledge holders and experts co-produced the workshop proceedings (Roué & Molnár, 2016) to provide indigenous and local knowledge-relevant information to the assessment. Authors of the assessment, represented by a liaison group on indigenous and local knowledge, reviewed relevant literature, supported by the task force. Furthermore, the assessment report drafts were made available to indigenous peoples and local communities through the external review process.

1.5.5 Data and indicators

Current knowledge on nature and its contributions to people is expanding rapidly (see **Figure 1.12** for a bibliographic search on biodiversity and ecosystem services), but is far from complete (see Section 1.6.1 which outlines differences in temporal, taxonomic and spatial coverage across Europe and Central Asia) (Cardinale et al., 2012). Regional and global publically available datasets present opportunities to expand this knowledge (e.g. the IUCN Red List of Threatened Species, Key Biodiversity Areas (specifically Important Bird and Biodiversity Areas (IBAs), and Alliance for Zero Extinction (AZE) sites), Protected Planet, the Global Biodiversity Information Facility). Many efforts have been made to combine data into metrics or indicators that provide aggregate information about status and trends of nature and of pressures. For instance, data such as observations and measurements are used as the basis for deriving indicators, or several measurements can be combined to derive an index.

IPBES uses indicators in conducting its assessments. Indicators are defined here as data aggregated in a manner – quantitative or qualitative - that reflect the status, cause or outcome of an object or process, especially towards targets such as the Aichi Biodiversity Targets or those included under the Sustainable Development Goals. Meaningful indicators require long-term monitoring data. Indicators can help to simplify the enormous complexity of datasets, variables, frameworks and approaches available to IPBES assessments. Complementing other forms of information and knowledge, standardized indicators have the potential to provide a common thread and quantitative point of comparison among assessments. They facilitate the synthesis envisioned for the IPBES global assessment, and ensure comparability and coherence across the regional assessments and between the regional or land degradation and restoration assessments on the one hand, and the global assessment on the other hand. They are useful tools for communicating the results of assessments and are a popular policy support tool used at multiple scales in tracking performance, exploring progress towards policy targets, and understanding the consequences of particular decisions, interventions or even future scenarios (Layke *et al*, 2012).

Following the IPBES conceptual framework, the Regional Assessment for Europe and Central Asia distinguishes indicators of nature (e.g. biomass), of nature's contributions to people (e.g. production of commercial crops), of contributions to good quality of life (e.g. amount of calories) and of values

(e.g. market or cultural values). The assessment has devoted efforts to fully referencing and documenting data sources to allow independent recalculation of indicators and indices and to allow tracing back to their component measures (Ash et al., 2010). It is, however, important to recognize the limitations of a given set of indicators in capturing the complexities of the “real world”, since indicators are restricted to what can be measured and for which there are available data. Notably, these limitations are especially significant when it comes to assessing the non-material contributions of nature to people and in quality of life. Moreover, the choice of indicators relates to diverse cultural perspectives. Hence, in IPBES assessments, indicators are subject to critical analysis and review from a diversity of experts. IPBES has consulted widely in arriving at a comprehensive list of biophysical and socio-ecological indicators that cover the conceptual framework (IPBES, 2017).

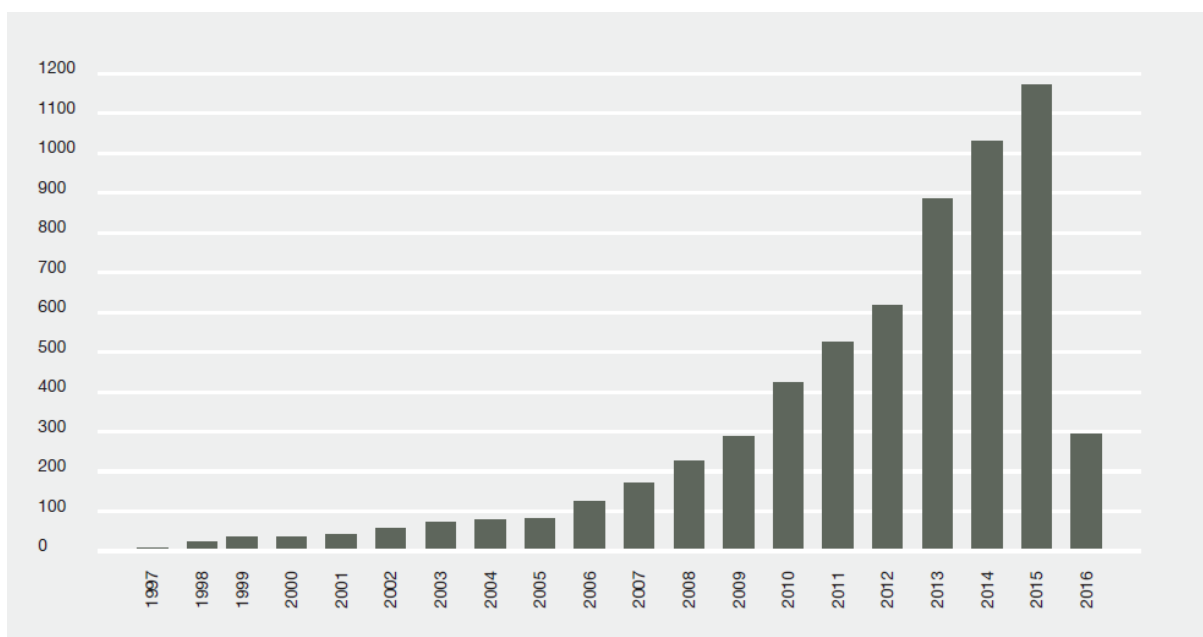


Figure 1.12: The exponential rise in numbers of scientific articles on the Web of Science produced from the search term [Biodiversity AND ecosystem services] (accessed on 26 April 2016). The y-axis shows the annual counts of articles, x-axis the year. In total 7,145 papers were located. Although not a perfect index of the geographical spread of knowledge the mention of a country (either by the location of authors, e.g. host institution, or the location of the study) gives a reasonable measure of expertise and focus of study on this topic. The countries associated with the most articles were, in descending order: USA, England, Germany, Australia, France, Canada, Netherlands, Spain, Sweden, Italy. Of these, 3,483 papers were associated with European countries, but none were associated with the five countries of Central Asia (limitations ensuing from this biased representation is discussed in 1.7).

1.5.6 The role of scenarios and models in the assessment

As other environmental studies have shown, (e.g. IPCC 2014; UK NEA 2011; UNEP 2012; Millennium Ecosystem Assessment 2005), models and scenarios represent effective means of addressing relationships between nature, its contributions to people, and good quality of life for the past, present and future. “Models” are qualitative or quantitative descriptions of key components of a system and of the relationships between those components. “Scenarios” are representations of possible futures for one or more components of a system, especially for the drivers of change in nature and its

contributions, including alternative policy or management options (Rounsevell & Metzger 2010). A scenario archetype describes a group of futures that are deemed “similar” according to the purpose of a specific analysis (Boschetti et al., 2016).

One of the key objectives in using scenarios and models is to move away from a reactive mode of decision-making, in which society responds to the degradation of nature and its contributions to people in an uncoordinated, piecemeal fashion. A proactive mode allows society to anticipate change and thereby to minimize adverse impacts and capitalize on important opportunities through thoughtful adaptation and mitigation strategies. The goals of using scenarios and models in assessments of nature and its contributions to people, are to better understand and synthesize a broad range of data (i) to assess future impacts of global changes, and (ii) to explore the implications of alternative social-ecological development pathways and policy options in support of decision-making (IPBES, 2016) (see **Figure 1.13**).

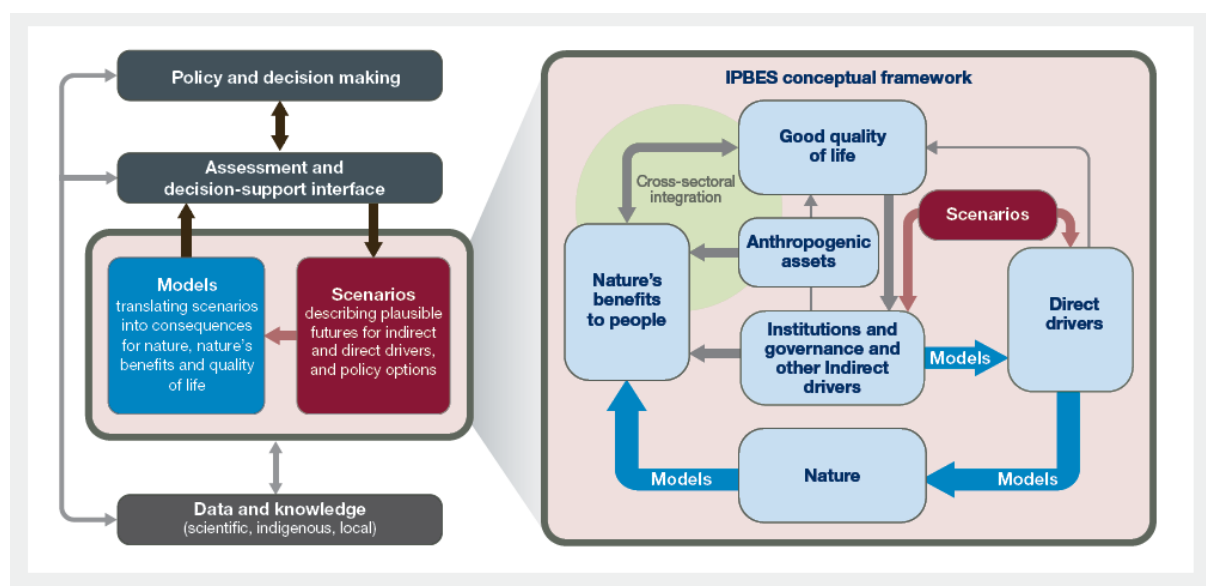


Figure 1.13: An overview of the roles that scenarios and models play in informing policy and decision-making (after (IPBES, 2016)). The left-hand panel illustrates how scenarios and models contribute to policy and decision-making through assessments, formal decision-support tools and informal processes. The right-hand panel provides a detailed view of the relationships between scenarios (burgundy arrows), models (blue arrows) and the key elements of the IPBES conceptual framework (light blue boxes, (Díaz et al., 2015)). Grey arrows indicate relationships between the different elements of the framework. The “cross-sectoral integration” element signifies that a comprehensive assessment of good quality of life will often involve the integration of modelling from multiple sectors (e.g., health, education and energy) addressing a broader range of values and objectives than those associated directly with nature and nature’s contributions.

Scenarios and models allow research questions to be addressed for which observational evidence is lacking (e.g. model applications across geographic space) or unavailable (e.g. scenarios of the future) (IPBES, 2016). They allow “what if?” studies to be conducted that cannot be undertaken in empirical experiments, and to explore alternative pathways toward visions or goals for the future (Rounsevell & Metzger 2010). Thus, scenarios can be exploratory by projecting different pathways from the present situation, or normative by analysing the pathways required to achieve future desired states or goals. The Europe and Central Asia assessment reports on both of these approaches. However, the importance of scenarios extends beyond the scientific or policy arenas. These tools can help to focus

investments and technology development, induce societal change, and support engagement with key stakeholders (UNEP, 2012). For example, the Regional Assessment for Europe and Central Asia has access to a large literature base derived from social surveys and participatory scenario development exercises that provide insight into local knowledge (Gramberger et al., 2015; Kok et al., 2015). This involves engagement with a broad range of stakeholders, including primary producers (e.g. farmers, foresters, fishermen) and individuals supporting decision processes (e.g. civil servants, government officials).

Scenarios and models support an understanding of the connections between all aspects of the IPBES conceptual framework. Scenarios and models can be used independently or in combination. An example of a combined use of both are integrated assessment models. Integrated assessment models allow linkages between system components to be explored in interconnected, social-ecological systems (Harrison et al. 2016; van Vuuren et al. 2012). An economic dimension to biodiversity loss enhances social and ecological considerations and the consequent impacts on the availability of ecosystem services. Thus, integrated assessment models allow experimentation and analysis of co-evolving processes within the social-ecological system across spatial and temporal scales. Particularly, by synthesizing various pieces of disciplinary scientific knowledge and indigenous and local knowledge, models help to qualitatively or quantitatively analyse the cause-effect relationships of, for example, biodiversity loss, and provide outputs for policy-oriented applications (Millennium Ecosystem Assessment, 2005).

1.6 Challenges in conducting the Regional Assessment for Europe and Central Asia

1.6.1 State of knowledge

Data gaps and uncertainties. The Regional Assessment for Europe and Central Asia draws on many different types of data and expert knowledge. Examples include large-scale quantitative data derived from remote sensing, data collected from field sampling of taxa at a range of scales and qualitative data collected by interviewing people. The challenge has been to combine such data into meaningful syntheses while acknowledging the differences in accuracy both within similar methods (in terms of sampling effort) and between methods. Complicating factors include: (i) the fact that the definition of biodiversity is often unclear (Cardinale et al., 2012) and there is a bias towards easily studied taxa (Maier & Feest, 2015); (ii) difficulty in quantifying the different types of anthropogenic and non-anthropogenic values (Pearson, 2016); and (iii) capturing knowledge from regions with little underlying scientific information (although this can be offset in part by the integration of indigenous and local knowledge).

Data collection as an ongoing process. Long-term and widespread data collection both for nature and its contributions to people can be expensive. Although citizen science offers exciting opportunities, it requires the potentially unjustified assumption that volunteers will engage in such projects and that data is of sufficient quality. That said, Europe and Central Asia has a number of ongoing data gathering exercises that can support the improvement of databases in the near term. These include the European Union's project Mapping and Assessment of Ecosystems and their Services, which encourages European Union member States to collect and map spatial data for a number of ecosystem service indicators (biodiversity.europa.eu/maes). The European Environment Agency has created the Biodiversity Information System for Europe (BISE) (<http://biodiversity.europa.eu>) and Water Information System for Europe (WISE) (<http://water.europa.eu/>) databases that are continually

updated. The European Commission has also funded the development of the Oppla web platform (www.oppla.eu) that is engaging with communities of practice across the science-policy-practice nexus to provide tested methods, data and case study examples of the operationalisation of natural capital and ecosystem services. Oppla is supporting the IPBES process by contributing towards the development of the catalogue of policy support tools on the IPBES website (www.ipbes.net). There is also a range of global data collection exercises for biodiversity that can generate data relevant to Europe and Central Asia (e.g. IUCN Red List of Threatened Species) and which, in some cases, already have explicit derivatives (e.g. <http://ec.europa.eu/environment/nature/conservation/species/redlist/>).

Outside of the European Union, the most consistent peer-reviewed activity for making inventories of the conservation status of endangered species is the development and maintenance of national red lists, while the current trends are usually reported in annual assessments of the state of environment and natural resources (e.g. see Ministry of Natural Resources and Environmental Protection of the Republic of Belarus (n.d.); Minprirody of Russia, (2016)). Such assessments are based on the outcomes of national programs of biodiversity monitoring, which are typically run by research institutes of national academies of science or national ministries of environments (or their equivalents). National red lists are based on national lists of endangered species and published as Red Books. The Red Book of Belarus is published about every 10 years (in 1981, 1993, 2006 and the new edition is pending as of 2017 (Ministry of Natural Resources and Environmental Protection of the Republic of Belarus, n.d.)). Others are one-off publications, such as the Red Book of Russia, published in 2001, while the actual red lists can be available as online databases. In Russia, red lists are kept (and subsequently published as a Red Book) by most of the members of the Federation (Federal State Budgetary Institution – Arctic and Antarctic Research Institute, n.d.-b). In addition, national academies of science or botanical and zoological NGOs or agencies of ministries of environment, maintain national inventories of plant or animal species (e.g. Herbarium of CBG NASB MSKH (n.d.)) or of the biodiversity of protected areas (e.g. Federal State Budgetary Institution – Arctic and Antarctic Research Institute (n.d.-a)). The initiatives driven by the non-governmental sector are usually less comprehensive, although some ambitious projects should not be overlooked, e.g. BIODAT in Russia (“Biodat,” 2017) or biodiversity monitoring in the Ukraine (“Biodiversity Monitoring in Ukraine,” n.d.).

Heterogeneity of data and knowledge across the region. Knowledge of biodiversity is not spread evenly across taxa and there is considerable bias in the coverage of different broad-level taxonomic groups both globally and within Europe and Central Asia (see **Figure 1.14** and **Figure 1.15**). Whilst over 1.64 million species have been described on Earth (“Catalogue of Life: 2016 Annual Checklist,” 2016) out of a global total of about 8 million (Mora et al., 2011), only 82,954 have been assessed by 31 October 2016 on the IUCN Red List of Threatened Species. At more detailed scales, full assessments have been made of smaller subsets of species within some groups including the following taxonomic groups: amphibians, reef-building corals, chameleons, seasnakes, sharks and rays, tarpons and ladyfishes, parrotfishes and surgeonfishes, groupers, tunas and billfishes, hagfishes, angelfishes, blennies, butterflyfishes, picarels, porgies, pufferfishes, seabreams, sturgeon, wrasses, freshwater caridean shrimps, cone snails, freshwater crabs, freshwater crayfish, lobsters, cacti, conifers, cycads, seagrasses and plant species occurring in mangrove ecosystems (Brooks et al., 2016). However, some groups have far less coverage, for example plants (7.1%), fungi and protists (<0.001%) and invertebrates (1.4%) (IUCN, 2017).

Europe and Central Asia supports 2,493 species that have been assessed on the IUCN Red List of Threatened Species. Of this group 13% are classified as threatened (Brooks et al., 2016). Of the taxa classified on the global-scale IUCN Red List of Threatened Species the Europe and Central Asia region holds 6.5% (see **Figure 1.16**). There are fewer data available in Central Asia than in the other three subregions. Although there is background knowledge of the role of many taxa in ecosystem functioning, there is far less known about their individual roles in systems; about what would happen

if they were removed from food webs; and about the services they provide as individual species. While there is some literature in this area, most is focused on plant studies, e.g. see Cardinale et al. (2012); Schwartz et al. (2000).

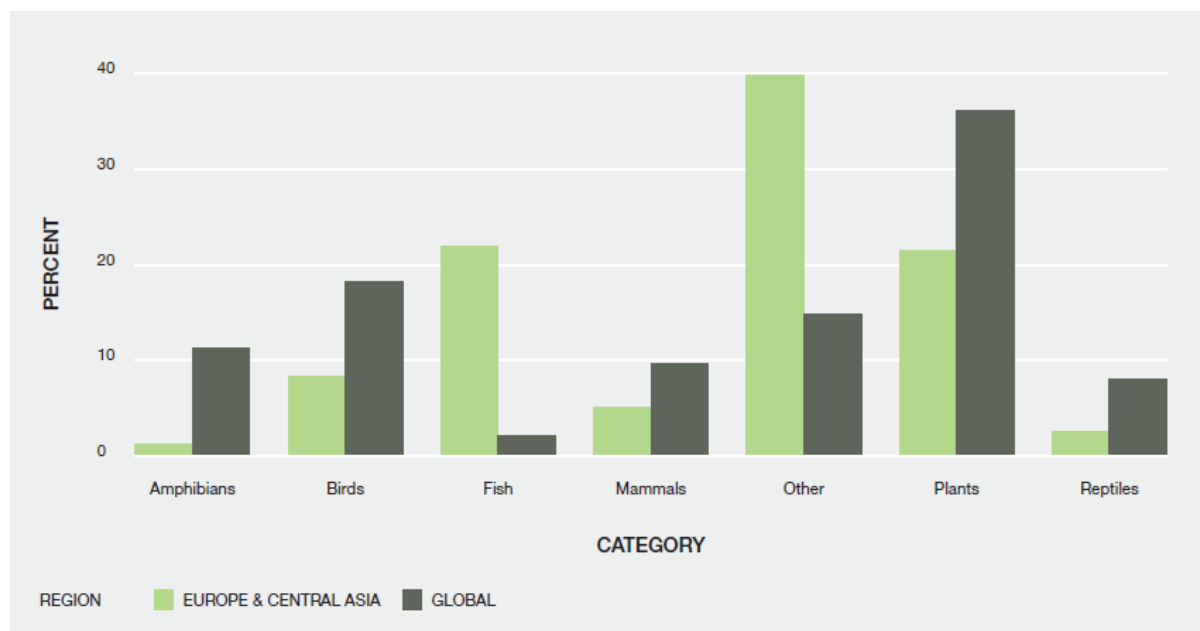


Figure 1.14: Proportion of classified taxa among different broad taxonomic groups classified in Europe and Central Asia compared with the global proportion (note that all categories combined sum to 100%). The IUCN Red List has classified proportionally more of some groups of taxa (such as fish) than have been classified globally. Data derived from The IUCN Red List of Threatened Species.

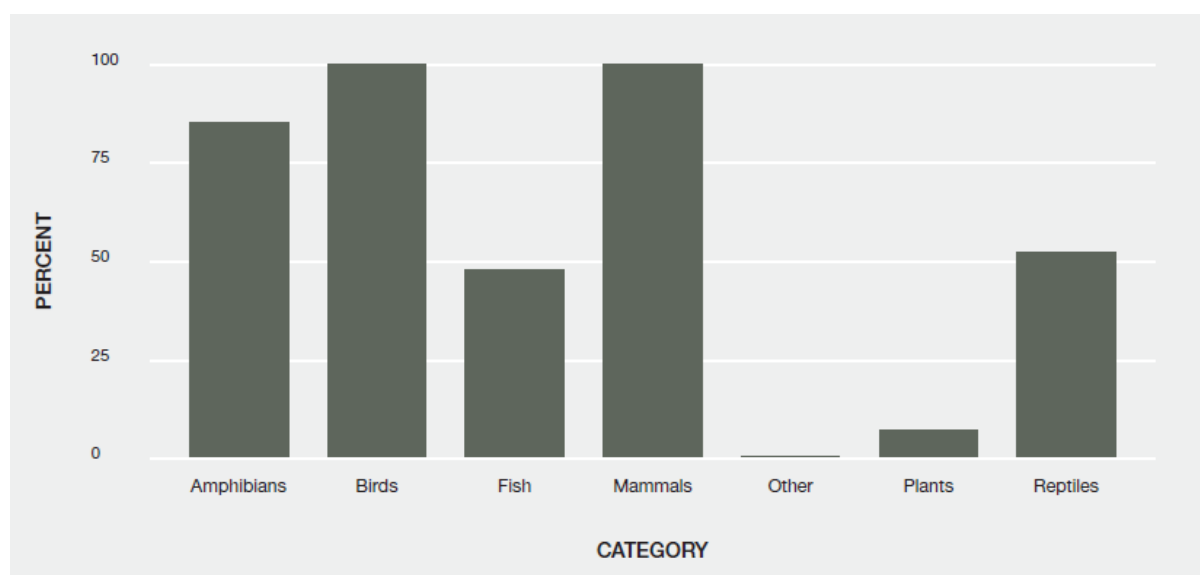


Figure 1.15: Proportion of taxa within each taxonomic category that have been classified globally. For example 100% of birds and mammals have been classified, but less than 1% of the known species of fungi. Data derived from The IUCN Red List of Threatened Species. Note the “other” category includes all of the remaining taxonomic groups (e.g. fungi).

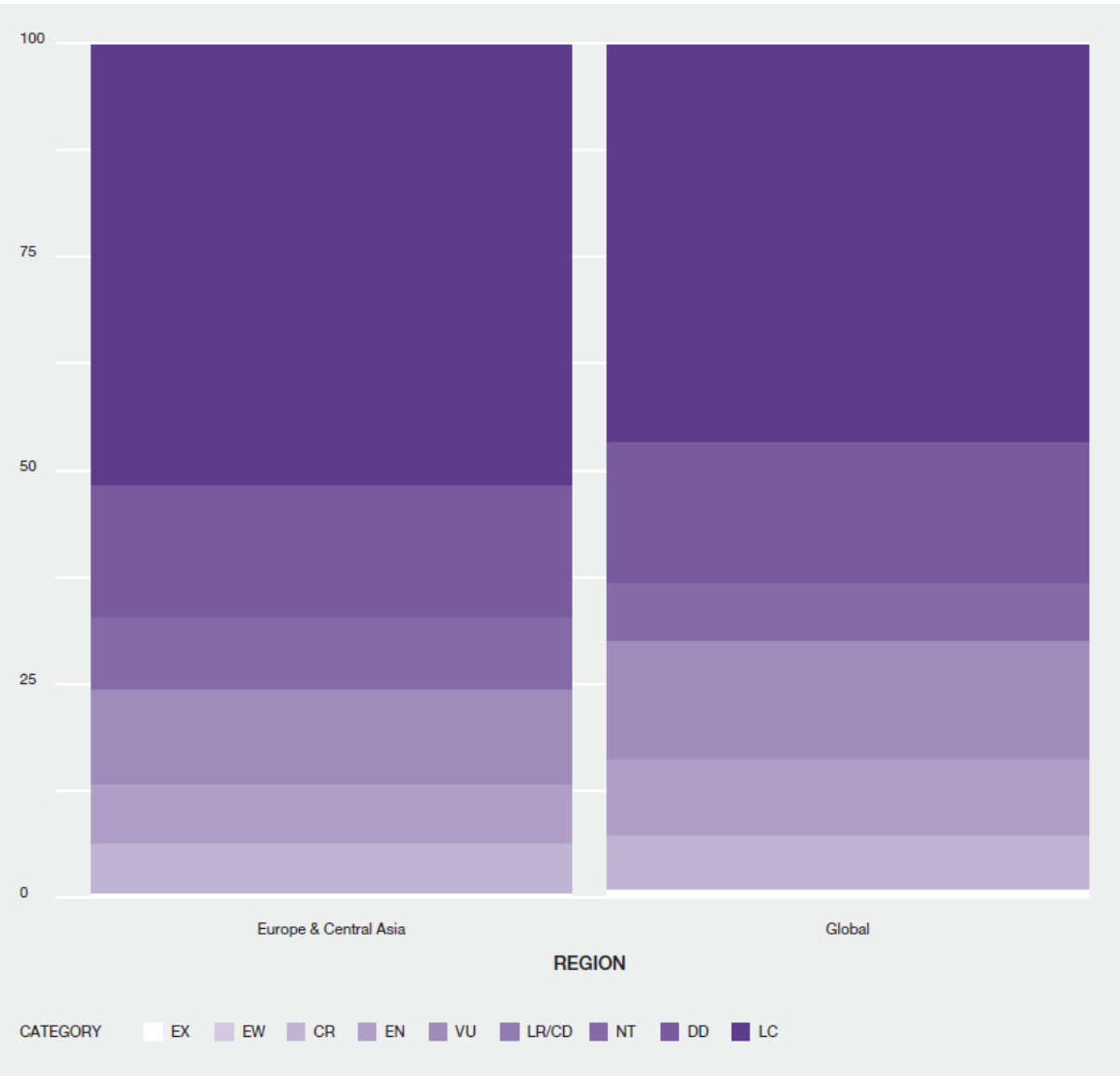


Figure 1.16: The percentage of species in different extinction categories in Europe and Central Asia compared with the global situation (EX, extinct; EW, extinct in wild; CR, critically endangered; EN, endangered; VU, vulnerable; LR, lower risk; NT, near threatened; DD, data deficient; LC, least concern). Proportionally there are fewer species classified as being at more severe threat from extinction in Europe and Central Asia than globally. Data derived from The IUCN Red List of Threatened Species.

1.6.2 Methodological limitations

Model and scenario uncertainty. Models as tools for quantitative or qualitative descriptions of nature, its contributions to people, and the intra and interrelationships therein, are simplifications of a complex reality. Hence, the limitations of representing complex realities and interactions are embedded within model uncertainty. A number of model inter-comparison exercises have sought to quantify model uncertainty for some components of the natural world (e.g. Alexander et al. (2016);

Prestele et al. (2016)). Scenarios, as descriptions of possible futures, contain the inherent uncertainties associated with socio-political, economic, technological and cultural drivers of change that affect nature. Dealing with scenario uncertainties is often done by creating different storylines that cover a range of possible futures, based on different sets of assumptions about future trajectories of key factors (e.g. population, income, technology development or consumption patterns (Rounsevell & Metzger 2010). Both models and scenarios also share the uncertainty associated with the input data upon which they are based, although the use of confidence intervals can help to make uncertainty more transparent.

Uncertainties in model and input data can often be greater than the differences between the scenarios themselves (Alexander et al. 2016; Dendoncker et al. 2008; Prestele et al. 2016) leading to conclusions about the need to run multiple ecosystem impact models to capture the full range of model uncertainties. Specific types of models such as integrated assessment models, have additional uncertainties associated with the propagation of errors through coupled sub-modules, e.g. (Brown et al., 2014; Dunford et al., 2014). There has been increased interest in moving from scenarios to probabilistic futures of natural and socio-ecological system change, but these methods are in their infancy. Moreover, ascribing probabilities to future events is extremely difficult in practice, in spite of being desirable within a risk management framework. An approach that combines scenarios with likelihoods is based on conditional probabilistic futures (Engström et al., 2016), in which future estimations of the likelihood of different future drivers are conditional on a scenario storyline (Rounsevell & Metzger 2010).

Scale (temporal/spatial/institutional). Assessing diverse values of nature over spatial, temporal and institutional scales is challenging, since these three scale types are interconnected. Spatial scales range from the interactions between the entire Europe and Central Asia region with other global regions, over aggregated large patterns and gradients within Europe and Central Asia down to local communities or smaller. Different organisms operate at different spatial scales, which makes the potential management of different taxa a challenge. Temporal scales involved in the Regional Assessment for Europe and Central Asia also vary: from the overarching sustainability principle spanning across generations, over the assessment of temporal data range (1950-2050, see 1.6.1), down to the varying ranges of data collected over multiple-year sampling campaigns or seasonal variations. A similar trade-off appears between aggregating comparable data for longer periods to capture broad and longer-term trends and the higher precision and specificity of short-term variations.

Institutional scales are a key issue in IPBES. Values will vary greatly between the perspectives of the general public, subnational governments, national Governments, supra-national institutions, NGO's, and businesses (see 1.3.1). Depending on the institutional scale, an assessment may find conflicting or contradicting valuations, with one not necessarily more valid than another. Whether nature, contributions of nature, or good quality of life are considered, different values between scales persist, as do interactions across scales. This suggests caution when synthesizing and interpreting findings of the assessment from a specific spatial, temporal and institutional context.

Difficulties in harmonizing data and indices, limitations of indices, knowledge types, and data types. Given the logistical and resource challenges in monitoring biodiversity or nature and its contributions to people (see Section 1.6) it is not surprising that indicators are commonly used to represent a wider suite of organisms or contributions. Such approaches are common in the Regional Assessment for Europe and Central Asia and, hence, it is important to mention general issues when interpreting such data. There are limitations in the use of ecological, economic and social indicators (e.g. Selomane et al., (2015); Stephens et al. 2015; Uuemaa et al., 2013), which are important to recognise. Moreover,

as the assessment draws upon a very diverse range of sources from many different places, harmonizing them across the whole of the region was a major challenge.

Gathering indigenous and local knowledge and integrating this knowledge within the assessment.

A major challenge is the difference in scale between the regional scope of the assessment and the nature of indigenous and local knowledge, which is grounded in local territories. Hence, seeking representativeness of the highly heterogeneous and complex indigenous and local knowledge covered by the scale of the assessment was a substantial challenge. The Regional Assessment for Europe and Central Asia sought to resolve this scale issue by collating messages from individual publications on indigenous and local knowledge and by utilising available reviews, (e.g. Hernández-Morcillo et al., 2013) in highlighting common aspects of the interlinkages between nature, its contributions to people and good quality of life. The indigenous and local knowledge produced from a specific IPBES dialogue workshop (Roué & Molnár, 2016) aimed to illustrate, not represent, the complexity of understanding, values and worldviews held by indigenous and local knowledge holders in the Europe and Central Asia region. For these reasons, the indigenous and local knowledge available for the Europe and Central Asia assessment remained at an early stage of methodological development.

Epistemology and expert judgement (by authors) in the assessment process. IPBES assessments use a four-box model of confidence attributed to their key findings (see Section 1.5.1) based on evidence and agreement and summarised in four main confidence terms. This ensures consistency in the communication of confidence across chapters and assessments. However, the use of confidence terms depends strongly on the author team's expert judgement as to the quantity and quality of supporting evidence and on the level of scientific agreement. This is why a reference to the chapter section is also provided with each key finding.

1.6.3 Issues beyond the scope of this assessment

Emerging questions beyond the scope of the assessment. While the assessment presents the best available information on nature and its contributions to people, it does not analyse available datasets to test new hypotheses or to validate existing ones. During the development of the assessment, new natural or human impacts on nature may have emerged. As the assessment process involves the use of current information, however, any new aspects cannot form part of this regional assessment.

Time cut-off for evidence/published literature. The literature and evidence sourced for this assessment has a standard timeframe, extending from 1950 to the end of April 2017.

Intrinsic values. The IPBES conceptual framework, unlike the ecosystem services concept, includes intrinsic values. The term intrinsic value has many different meanings (Batavia & Nelson, 2017). For this assessment, we follow the definition provided by Jacobs et al. (2016) and Pascual et al. (2017), which refers to inherent value, i.e. *the value something has independent of any human experience or evaluation*. Since intrinsic value can be recognized, but not quantified, by humans it is not the target of any valuation process or assessment.

Disclaimer and liability - drawing inferences from general patterns. It is important to recognise that, while broad patterns exist, their exact nature in specific contexts may differ. For example, while general patterns of increased ecosystem functioning with increased biodiversity have been widely reported, mostly from experimental botanical and zoological studies, exceptions to this general rule also need to be considered (Hector & Bagchi, 2007; Cardinale et al., 2012; Schwartz et al., 2000). Moreover, many of the relationships reported between drivers, nature (biodiversity) and nature's contributions to people (including ecosystem services) in the literature are associative (e.g.

correlative) and thus, in contrast to experimental evidence, not necessarily causal. Particular caution is needed when applying existing knowledge to novel situations, because extrapolating outside of the bounds of where data were collected, might be misleading. It is worth noting, however, that methods that formally acknowledge uncertainty (e.g. scenario testing and modelling) are useful in this respect.

1.7 Roadmap to the assessment

1.7.1 What each of the six chapters covers

Chapter 1 sets the scene. Chapter 1 offers a roadmap to all chapters of the Europe and Central Asia assessment. It explains how the assessment has been developed and introduces both the purpose of the assessment and the geographical characteristics of the region. The chapter also provides an overview of the content, and introduces the most important concepts and methods used in the following chapters.

Chapter 2 shows how nature contributes to people's quality of life. Chapter 2 addresses trends in nature's contributions to people and the interactions between nature's contributions to people and their quality of life. It assesses the status, trends and future dynamics of nature's contributions to people including material, regulating and non-material contributions. It also assesses the different impacts of changes in these contributions to the quality of life of people in terms of instrumental and relational values.

Chapter 3 provides insight into the relationship between biodiversity and ecosystem functioning and services, and into the dynamics of the major ecosystems of Europe and Central Asia. Chapter 3 assesses the existing knowledge on the relationship between biodiversity and ecosystem functioning and ecosystem services, and on the status, trends and future dynamics of nature and the processes underpinning nature's contributions to people. It deals with the entire scope of biodiversity including varying functional characteristics of taxa as well as interactions among living organisms in terrestrial and marine systems and trends in important ecosystem functions. It provides a synthetic analysis of the impact of drivers on the major ecosystems (units of analysis) and taxa.

Chapter 4 documents the drivers of change. Chapter 4 documents the status and trends in both direct and underlying indirect drivers of change that affect nature and its contributions to people across subregions and units of analysis.

Chapter 5 explores possible futures. Chapter 5 provides an integrated and cross-scale analysis of interactions of the natural world and human society. It explores plausible futures that take account of different values through scenario archetypes. It also assesses visions for the future and provides an analysis of the pathways that could lead to realising these visions.

Chapter 6 indicates opportunities in governance and policy. Chapter 6 explores governance options and institutional arrangements for better consideration of nature and nature's contributions to people in public and private decision-making. It also considers the opportunities for a wide range of actors and sectors for the conservation and sustainable use of nature, and the sustained provision of nature's contributions to people in Europe and Central Asia. It highlights areas for successful integration and assesses major categories of policy instruments.

1.7.2 How do the chapters address the policy-relevant questions?

The five general IPBES policy questions on: urgent worldwide knowledge demands on the importance of nature for the human species (Question 1); the current change of nature and its consequences (Question 2); the causes of this change (Question 3); opportunities for policies and interventions (Question 4); and the identification of related knowledge gaps (Question 5) are addressed in Chapters 2 to 5 of this assessment. Questions 1 to 4 guide Chapters 2 to 5, and question 5 on knowledge gaps is addressed as a sub-section in each of Chapters 2-5. Chapter 6 provides governance options for private and public actors based on the findings of Chapters 2 to 5, and it addresses the Europe and Central Asia specific questions on nature-based solutions (Question 6), and how sectoral policies and innovative policy instruments encourage opportunities arising from the contributions of nature to good quality of life (Question 8). Question 7 on the effects of production and consumption and cross-regional linkages is covered by Chapters 2 (see e.g. 2.2.4), 4 (indirect drivers), 5 (scenarios) and 6 (governance options) (see **Figure 1.17**).

The responses to these questions, reflecting the requests of different stakeholders, are highlighted within each section in the key findings. Chapter 1 sets the scene for the different chapters by introducing the important issues discussed in the other chapters, which lead to the assessment's main messages. Transparently presenting the broad evidence base for these main messages and key findings is considered essential for not only the credibility, but also the legitimacy and reliability, of the Regional Assessment for Europe and Central Asia.

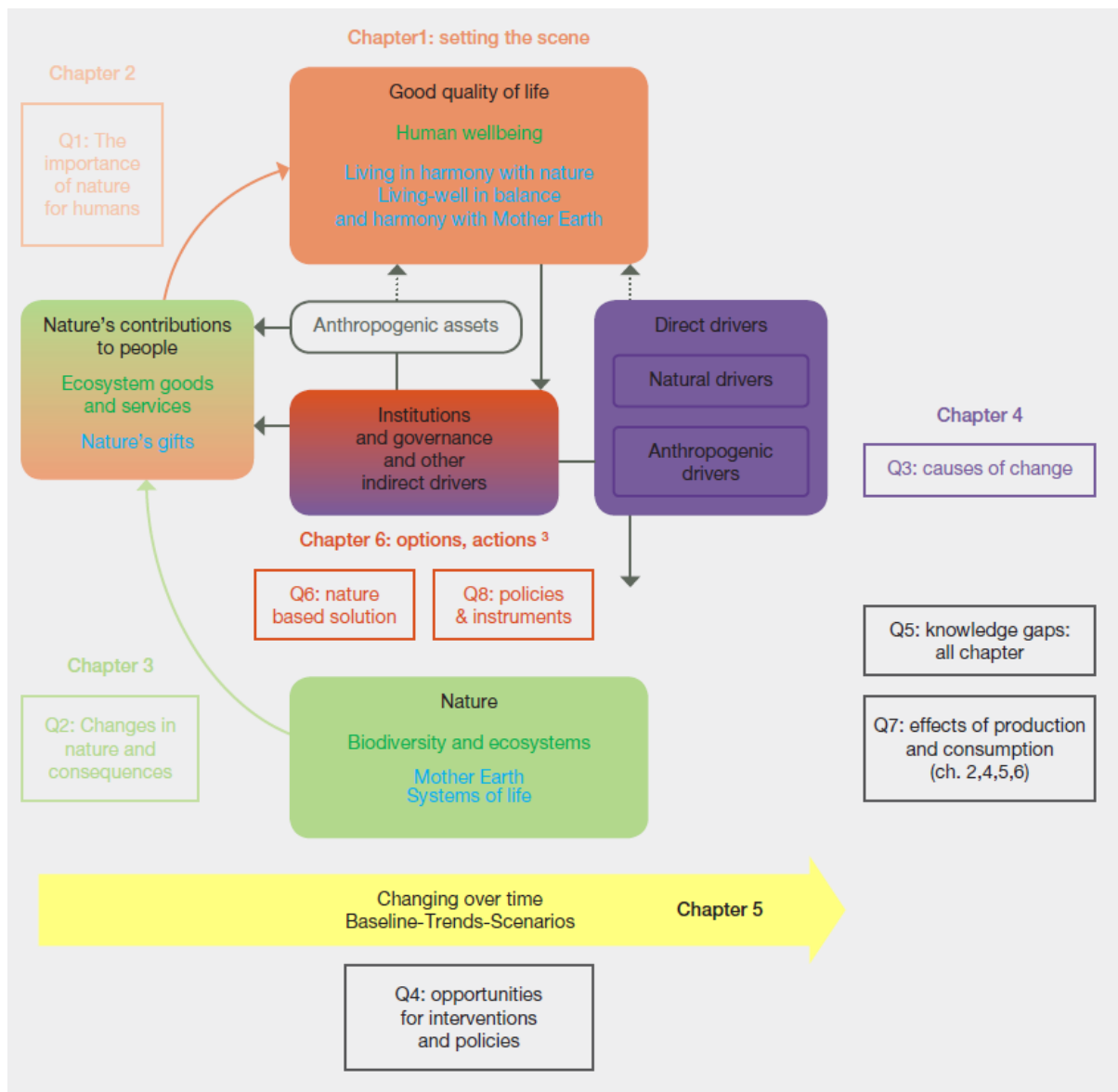


Figure 1.17: Roadmap linking the chapters to the IPBES conceptual framework and the requests by Governments and multilateral environmental agreements.

1.7.3 What will the Regional Assessment for Europe and Central Asia lead to?

Scientifically sound assessment reports review, summarize and evaluate the evidence related to a specific problem, and provide conclusions that are accessible not only across different disciplines of science, but also for decision-makers and the general public. Previous examples have shown the importance of such assessments. The Intergovernmental Panel on Climate Change (IPCC) reports, for example, have played a major role in securing international consensus for the Paris climate agreement and the Sustainable Development Goals. The IPBES pollination assessment has resulted in a substantial rise in public awareness of the loss of pollinators and has received significant policy interest. Both of these assessments have identified important knowledge gaps and have, therefore, increased research (and funding) interest in scientific studies address these gaps. Since the IPBES Regional Assessment for Europe and Central Asia responds to a direct request from the Governments

1963 of IPBES member States, it aspires to inform decision-makers at local, national and international levels,
1964 to raise public awareness and to stimulate new research.

1965

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1.8 References

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2 Chapter 2: Nature's contributions to people and quality of life

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Executive summary

Nature's contributions to people in Europe and Central Asia have changed markedly since the 1950s, promoting changes in the quality of life of its societies (*well established*). The ecosystems of Europe and Central Asia are currently delivering multiple contributions, although there is evidence of negative trends between 1960 and 2016 in the majority of regulating and some non-material contributions (*well established*) (2.2.1, 2.2.3, 2.2.5). Of nature's contributions to people in Europe and Central Asia, about 44% have been assessed as declining, particularly regulating contributions and learning derived from indigenous and local knowledge (*well established*) (2.2.1, 2.2.3, 2.2.5). The increasing trends in the delivery of specific material contributions, such as food and biomass-based fuels, have come at the expense of the long-term deterioration of regulating contributions (*well established*) (2.2.1, 2.2.2, 2.2.5). Some key regulating contributions, such as habitat maintenance, pollination, regulation of freshwater quantity, regulation of freshwater quality, formation and protection of soils, and regulation of floods decreased due to intensified management practices designed to produce more crops, livestock, aquaculture, woodfuels and cotton. Furthermore, the increasing demand in Western and Central Europe for food, wood products and biofuels is causing the impairment of ecosystems and nature's contributions to people in other regions of the world (*established but incomplete*) (2.2.2.3, 2.2.4, 2.3.4).

Trends of nature's contributions to people are consistent across the subregions of Europe and Central Asia. Declining trends are reported in Central Europe (61% of the scientific evidence), Western Europe (55%), Eastern Europe (54%) and Central Asia (48%). Increasing trends are mostly reported for Western Europe (35% of scientific evidence) (*established but incomplete*) (2.2.5).

Across all subregions of Europe and Central Asia, continuing declines in nature's capacity to provide regulating contributions to people since the 1960s are of particular concern, especially in the cases of nursery habitats of fish species and breeding and overwintering areas for migratory species, pollination, freshwater flow regulation, freshwater quality regulation, regulation of floods, soil quality and erosion control (*well established*) (2.2.1). However, since the 1990s an improvement in some of these and other regulating contributions from nature to people (i.e. air quality regulation and removal of animal carcasses) in Western and Central Europe occurred due to the implementation of European Union policies (*established but incomplete*) (2.2.1). Since the 1960s, the impacts of land-use change on natural ecosystems and inappropriate management practices in agriculture and fisheries have caused declines in pollinators (2.2.1.2), in regulation of freshwater quality (2.2.1.7), in erosion control and soil quality (2.2.1.8) and in fluvial flood regulation (2.2.1.9) in the four subregions (*well established*). The increases in forest area since the 1960s across parts of Europe and Central Asia have increased carbon storage in those areas, contributing to climate regulation. Increased urban green infrastructure improved the regulation of air temperature in cities and air quality regulation (2.2.1.3, 2.2.1.4). The declines of seagrass beds and kelp forests due to global warming, fishing pressure and marine pollution in the Atlantic, Baltic and Mediterranean Seas have negative consequences for the provision of nursery habitats for fish (2.2.1.1) and regulation of ocean acidification (2.2.1.5) (*established but incomplete*). Nevertheless, these marine habitats may increase in the Arctic Ocean led by seawater warming and will possibly enhance the regulation of ocean pH in the future (2.2.1.5) (*established but incomplete*). After the sharp declines of vultures since the 1950s, the recent recovery of vertebrate scavengers mainly due to natural recovery of populations and also the reintroduction and conservation programmes in Western Europe, has enhanced the removal of animal carcasses (2.2.1.5) (*well established*).

Nature's material contributions to people in Europe and Central Asia are highly diverse, including food, energy supply, materials that enter industrial processes, and medicinal resources (*well established*) (2.2.2.1). There are inherent trade-offs amongst those material contributions derived from different forms of land use and management. Trends in the use of material contributions reflect socio-economic change and market forces, but also limits to natural capacity (2.2.2.1) (*established but incomplete*). Intensification of management practices, technology, and investment have led to higher production levels for particular material contributions with high market value, including food and biofuels (2.2.2, 2.3.5). The production of some products has experienced substantial growth in the region, particularly in Eastern Europe and Central Asia, including maize, cereals, fruits and vegetables, and meat (*well established*) (2.2.2.1.1). Capture of marine wild fish in the region reached a peak in the 1990s and since then has reduced by about 30% to permit recovery of stocks (*established but incomplete*) (2.2.2.1.2). This reduction was compensated for by a rapid expansion of aquaculture (*well established*) (2.2.2.1.2). Intensive extraction of food and materials combined with policy failures has driven the decline of natural resources, particularly of wild fish and maerl (2.2.2.1.2, 2.2.2.3.3). Also, the loss of indigenous and local knowledge has affected the use of medicinal plants and guard dogs for protecting livestock (2.2.2.3.4, 2.2.2.4). As a result of management for sustainable use, wood production in Europe and Central Asia has been stable since the 2000s and currently about 23% of this production is used as woodfuel (2.2.2.2). Production of biofuel and biodiesel remains small relative to woodfuel and the potential for expansion is limited due to impacts on ecosystems (*established but incomplete*) (2.2.2.2).

Nature's non-material contributions to people in Europe and Central Asia have implications for quality of life by providing opportunities for learning, inspiration, identity development, and physical and psychological experiences (*well established*) (2.2.3). Different measures for these contributions show contrasting trends and geographical unevenness across Europe and Central Asia (*well established*) (2.2.3). There are contrasting trends in measures for learning and inspiration. Informal learning based on interactions with nature has expanded partly due to increases in recreation and tourism linked to sustainable environmental management that promotes knowledge of nature (*well established*) (2.2.3.1.1). Other forms of informal learning and knowledge are in decline and can be linked to a loss of indigenous and local knowledge and linguistic diversity which is the basis of different forms of indigenous and local knowledge relating to nature. Across Europe and Central Asia, 12% of all languages are categorized as critically endangered and 14% as vulnerable (*well established*) (2.2.3.1.2). The overall evidence for physical and psychological experiences indicates an increasing trend. The demand for nature-based recreation and leisure has grown in Western Europe and in 2015 31% of European Union adults surveyed indicated that nature is their main reason for going on holiday, up from under 10% in 2008 (*well established*) (2.2.3.2, 2.3.3). Thirty-eight per cent of the European Union is characterized by a high outdoor recreation potential, but the places that can be used for nature-based recreational and aesthetic experiences in Western Europe are becoming fewer due to land use changes including urbanization, land-use intensification, rural abandonment, disappearance of common lands and water pollution (*well established*) (2.2.3.2). The support of identities relates to virtues and principles rather than to enjoyment resulting from physical and psychological experiences, but it is not possible to identify clear trends for this contribution from nature (*well established*) (2.2.3.3). Nevertheless, it is reflected in attitudes towards nature and, in the European Union, 76% of people agreed with the statement that "we have a responsibility to look after nature" (*well established*) (2.2.3.2). In support of their identities, people attribute an existence value to species and ecosystems, especially iconic and emblematic species (*well established*) (2.2.3.3). Species found in European and Central Asian forests, such as moose; and in marine waters, such as whales, are particularly highly valued (*established but incomplete*) (2.2.3.3). The maintenance of options is a

contribution that depends on the existence of biodiversity, and its status and trends are reflected by those of biodiversity measures, including phylogenetic diversity. Society's appreciation of maintenance of options is only moderate, as indicated by previous assessments of Europe and Central Asia, and by the recent call for greater appreciation of maintenance of options from conservation NGOs (*established but incomplete*) (2.2.3.4).

Europe and Central Asia is currently food secure despite a decline in pollination; degradation of agricultural soils; decreases in water availability; increases in floods and droughts; decreases in wild fish catch; competition from agriculture with other land uses such as forests and urbanization; and loss of supporting farmer identity and food-related indigenous and local knowledge (*well established*) (2.3.1.1, 2.2.1.2, 2.2.1.5, 2.2.1.7, 2.2.1.8, 2.2.2.1, 2.2.3.1). This has been possible because of the mechanization and intensification of agriculture and because the region depends partly on imports of food and agricultural inputs as well as on large-scale land acquisition abroad (*established but incomplete*) (2.3.1.1). Food availability depends on different contributions from nature, particularly food production, protection of soils, regulation of water quantity and pollination. Food production from agriculture in Europe and Central Asia increased by 56% between the 1960s and the 1990s until the dissolution of the Soviet Union, the Yugoslav wars and the MacSharry reform of the European Union Common Agricultural Policy. Because of efforts to reduce surplus production in Western Europe between the 1960s and the 1990s, agricultural production has declined by 33% since the 1990s (*well established*) (2.2.2.1.1). This has been offset by an increase in imports from outside of Europe and Central Asia, primarily from South America and Africa (2.2.2.1.2, 2.2.4) and by large-scale acquisition of land in other regions of the world (0.63% of croplands worldwide, 0.57% acquired by countries from Western Europe) (2.3.1.1). There has also been a decrease in wild fish catches since the 1990s, partly due to more sustainable management practices. This decrease was compensated by an increase of 2.7% in fish production from aquaculture since 2000 (*established but incomplete*) (2.2.2.1.2).

Food quantity and quality depend upon soil quality, regulation of water flows and floods, pollination and food-related indigenous and local knowledge. Erosion of agricultural soil affects about 25% of agricultural land in Europe and Central Asia, and a decline of organic matter in agricultural soils has triggered decreased productivity in Central Asia (*established but incomplete*) (2.2.1.8). However, between 2000 and 2010, erosion control in the EU-27 increased by an average of 9.5%, and by 20% for arable lands, partly due to agricultural practices promoted by the Common Agricultural Policy (2.2.1.8). Since 1980, frequency and severity of floods have increased across Europe and Central Asia due to heavy precipitation events and decreased capacity to regulate fluvial floods (*established but incomplete*) (2.2.1.9), thus impacting crop productivity. Since 1961, Mediterranean and Central Asian countries have become more pollinator dependent due to their substantial production of highly pollinator-dependent fruits (*established but incomplete*) (2.2.1.2). However, the diversity, occurrence and abundance of wild insect pollinators have declined since the 1950s and severe losses of western honey bee populations have occurred in many Western European countries and former-USSR countries since 1961 (*established but incomplete*) (2.2.1.2). The loss of indigenous and local knowledge related to farming can affect food security by undermining intergenerational knowledge exchange within farming communities and contributing to the depopulation of rural areas (*established but incomplete*) (2.2.3.1.2, 2.2.3.2.1, 2.3.1.1).

Nature contributes in a range of ways to safe drinking water that is currently ensured for 95% of the people in Europe and Central Asia, despite a 15% decrease in water availability per capita since 1990 (*well established*) (2.3.1.3). Access to clean water depends strongly on the regulation of both water quality and water quantity. These two regulating contributions have been impaired by pollution and

overexploitation of freshwater bodies and the decrease in the areal extent of floodplains and wetlands (*well established*) (2.2.1.6, 2.2.1.7). However, the rate of decrease in water quality has lessened in the last decade in Western Europe, due to the implementation of the Water Framework Directive (*established but incomplete*) (2.3.1.3, 2.2.1.7). Access to drinking water is currently sufficient in Western and Central Europe (>99% of people), while Eastern Europe (95%) and Central Asia (85%) have had lower, but increasing, access to drinking water since 1995 (*well established*) (2.3.1.3). Water extraction as a percentage of renewable water resources decreased from 30 to 15% between 1993 and 2012 (*well established*) (2.3.1.3). However, overall water availability per capita has decreased by 15% since 1990, while this decrease was 42% since 1960 in Western Europe (*well established*) (2.2.1.5). Water scarcity in most countries of the European Union has decreased slightly since the 1990s, but over-exploitation still threatens freshwater resources (*established but incomplete*) (2.3.1.3). The Mediterranean region is facing scarcity of water (*established but incomplete*) (2.3.1.3).

Access to sufficient quantities of clean water also depends on water quality and water flow regulation (*well established*) (2.2.1.6, 2.2.1.7). Water quality regulation has decreased in the region since the 1950s, due to the declining naturalness of freshwater ecosystems and areal extent of wetlands (*well established*) (2.2.1.7). Between 2009 and 2015, the coverage of water bodies in the European Union with a “good ecological status” decreased from 43% to 32% (2.2.1.7). However, water quality in Western Europe has improved during the last decade due to the implementation of the Nitrates and Water Framework Directives (*well established*) (2.2.1.7). In Central and Eastern Europe, water quality is decreasing (*well established*) due to increased water pollution and the conversion of natural ecosystems (2.2.1.7). Water flow regulation shows mixed, but generally decreasing trends for the region, particularly in Western and Central Europe between 2000 and 2011 (*established but incomplete*) (2.2.1.6).

Some areas of research into linkages between nature and health have illustrated the value of biodiversity and most of nature’s contributions to people for human health (*well established*) (2.3.2). These linkages include the contribution of biodiversity and nature’s contributions to people to contemporary and traditional medicine, and to healthy nutrition through dietary diversity and support for food security (*well established*) (2.2.2.4, 2.3.2, 2.3.2). Dietary diversity, however, is not necessarily a good indicator of healthy nutrition: a relatively high diversity of unhealthy diets in Western Europe through increases in fat and protein supply can contribute to increases in obesity rates (*well established*) (2.3.1.1). Other linkages between nature and health include the influence of biodiversity and nature’s contributions to people on infectious disease risk (*unresolved*) (2.3.2.2), and the value of green spaces in promoting mental health and physical fitness (*established but incomplete*) (2.3.2.1). There has been a decline in indigenous and local medical knowledge across Europe and Central Asia (*well established*) (2.2.2.4), but medicinal plants have been increasingly used in complementary and alternative medicine outside of local and indigenous communities in recent decades (*established but incomplete*). Unsustainable patterns of exploitation threaten the survival of some medicinal plants (*established but incomplete*) (2.2.2.4).

Urban dwellers across Europe and Central Asia value green spaces for health, psychological wellbeing and emotional attachment (*well established*) (2.2.3.2). Increased urbanization poses significant challenges for human health – including a rise in non-communicable diseases associated with modern lifestyles, such as obesity, cardiovascular diseases, depression and anxiety disorders, and diabetes (2.3.2). Efforts to increase access of urban dwellers to green space and open countryside may help address some of these health issues through beneficial physical and psychological experiences (*established but incomplete*), though more research is needed into differentials between communities

and social groups in terms of access to greenspace and the health benefits obtained from them (*unresolved*) (2.3.2).

The value of nature's contributions to cultural heritage, identity and stewardship is indicated through people's engagement with nature for leisure and tourism, spiritual and aesthetic experiences, gathering of wild food, learning, developing indigenous and local knowledge and also by the desire of people, social groups and governments to protect and conserve areas and iconic species even when they do not use them (*well established*) (2.2.3). There has been a loss in knowledge of ecosystems and species linked to a marked general decline in indigenous and local knowledge and linguistic diversity (*well established*) (2.2.3.1.2). Protected areas, as indicators of valued and iconic places, have grown in number and extent so that globally the proportion of the Earth's surface protected has risen from 8% in 1990 to 14.7% in 2016 (*well established*) (2.2.3.2). The designation of protected areas, however, is geographically uneven in Europe and Central Asia with relatively few areas in Central Asia (2.2.3.3, 2.3.4) (*well established*). Protected areas and other green spaces have increasingly been used since 1950 for tourism, leisure, formal and informal learning with outdoor learning often providing additional value for skill and knowledge development for teachers and learners (*well established*) (2.2.3.1, 2.3.3). In some countries interactions between material and non-material contributions to cultural practices enhance identity, such as berry and mushroom picking (*well established*) (2.3.3). Shepherd's attach considerable identity value to guard dogs, especially to breeds associated with particular geographical areas (*well established*) (2.2.2.3.4). The belief systems of many peoples are strongly influenced by spiritual and religious interactions and ecosystems are viewed as alive in many indigenous and local knowledge systems in Europe and Central Asia (*well established*) (2.3.3). The decline in linguistic diversity weakens indigenous peoples' stewardship, heritage and identity especially among young members of these communities as it results in a loss of knowledge of ecosystems and species (*well established*) (2.2.3.1.2, 2.3.3). Indigenous and local knowledge has significant value for some local communities in Europe and Central Asia contributing to land rights claims, fisheries management and economic development linked to visitors consuming local products and experiencing lifestyles linked to indigenous and local knowledge (*established but incomplete*) (2.3.3).

Nature in Europe and Central Asia is important for delivering a wide range of contributions, which are valued by people. These values are expressed in multiple dimensions, including through economic markets, willingness to pay or cultural preferences (*well established*) (2.3.5). Integrated valuation approaches demonstrate that nature's contributions have substantial monetary and non-monetary values that can inform policy goals (*well established*) (2.3.5). Regulating and non-material contributions are as important in terms of value as material contributions (*established but incomplete*) (2.3.5.2, 2.3.5.3). Traditionally, nature's material contributions have been valued based on market prices and in this assessment monetary values are standardized to a common currency and base year (International \$ 2017). Mean net profits of nature's material contributions to people from agricultural production across EU-28 countries ranged from \$233 / ha / yr (cereals) to \$916 / ha / yr (mixed crops), while wood supply from forests was \$255 / ha / yr (*established but incomplete*) (2.3.5.1). Evidence from Europe and Central Asia demonstrates that nature's regulating contributions to people also have significant non-market monetary values and these are higher than non-market values for material and non-material contributions (*established but incomplete*) (2.3.5.2, 2.3.5.3). For example, habitat creation and maintenance is estimated to have a median value of (2017) International \$ 765 / ha / yr (*unresolved*) and regulation of freshwater and coastal water quality is estimated at (2017) International \$ 1965 / ha / yr (*established but incomplete*) (2.3.5.2). Nature's non-material contributions to people, such as physical and psychological experiences have a median value of (2017) International \$ 1117 / ha / yr (*unresolved*), while other non-material contributions were

demonstrated to be the most valued contributions by people in social-cultural valuations (*established but incomplete*) (2.3.5.2, 2.3.5.3). The (often large) ranges in values of nature's contributions reflect heterogeneity of preferences across regions, social groups, local contexts and methodological differences (*established but incomplete*) (2.3.5.2, 2.3.5.3). This assessment has demonstrated the importance of nature's contributions to people in terms of their market, non-market monetary and socio-cultural values. Hence, there is strong evidence to support the inclusion of the plurality of values in policy goals such as the Aichi Biodiversity Targets and Sustainable Development Goals (2.3.5.4).

Nature's contributions to quality of life of societies in Europe and Central Asia are not equally experienced across different locations and social groups across the region, resulting in distributional inequity (*established but incomplete*) (2.3.4). The benefits derived from nature's contributions and the harm from a loss of nature's contributions are geographically uneven, which creates distributional inequity as the impacts on quality of life of changes in ecosystems are linked to where beneficiaries live (*established but incomplete*) (2.3.4). There is also a time component as ecosystem service utilization today may destroy the basis for future service provision (*established but incomplete*) (2.2.3.4). 15% of people in Central Asia lack access to safe drinking water compared to only 1% in Western Europe (*well established*) (2.3.1.3, 2.3.4.2). However, intra-regional equity in the access to food and a balanced diet is increasing (*well established*) (2.3.1.1). Equal access to food can be threatened by large scale land-acquisition by Western European organizations in Central and Eastern Europe and Central Asia as it compromises the right of people in these areas to control their own food systems (*established but incomplete*) (2.3.1.1). In the European Union, access to green spaces is not equally distributed among the inhabitants of cities (*established but incomplete*) (2.2.3.2, 2.3.4.2). Public access to forests for recreational experiences is uneven across the countries of Europe and Central Asia with high levels of access to 98-100% of forest and other wooded land in Nordic and some Baltic countries as well as in several Central Europe countries including Bosnia and Herzegovina, Slovenia and Serbia. Lower levels of access are found in some Western Europe countries such as UK (46%) and France (25%) (*well established*) (2.3.4.2).

Europe and Central Asia uses more renewable natural resources than are produced within the region, either through overuse or net import, as indicated by the negative difference (deficit) between biocapacity (production) and ecological footprint (consumption) (*well established*) (2.2.4). **The region depends on net flow imports of renewable natural resources and material contributions from nature (*well established*) (2.2.4).** **Western and Central Europe and Central Asia have a biocapacity deficit while Eastern Europe has a reserve (*well established*) (2.2.4).** Western Europe's ecological footprint is 5.1 global hectares per person, while its biocapacity is 2.2 hectares. Central Europe's footprint is 3.6 hectares (2.1 ha biocapacity); Eastern Europe's is 4.8 hectares (5.3 ha biocapacity) and Central Asia's is 3.4 hectares (1.7 hectares biocapacity) (*well established*) (2.2.4). The regions footprint negatively affects biodiversity, food security and other contributions from nature to people in other parts of the world (*established but incomplete*) (2.2.4, 2.3.4). Human appropriation of net primary productivity (HANPP) is a measure that assesses biomass extraction from ecosystems for food, fodder, fibres and bioenergy and for large parts of Western Europe, HANPP is lower than HANPP embodied in consumption indicating a reliance on regions outside of Western Europe (*well established*) (2.2.4). HANPP for Central and Eastern Europe and Central Asia is similar or slightly higher than HANPP embodied in consumption, but the European Union has been increasingly importing embodied HANPP especially from South America (*well established*) (2.2.4). There are significant differences in interregional flows of nature's contributions to people across subregions: Central and Western Europe import more contributions than Eastern Europe and Central Asia (*well established*) (2.2.4). Food availability in Central and Western Europe relies significantly on land for crop production in Brazil, Argentina, China and the United States of America (*well established*) (2.2.4). Western Europe

2778 became less self-sufficient in crop production between 1987 and 2008, while the rest of Europe and
2779 Central Asia has become more self-sufficient (*well established*) (2.2.4).

2780 **Foreword to Chapter 2**

2781 *“This is like home, you can’t tell it. It has to be felt. This is the single sentence you can say. You don’t*
2782 *have to add anything else. In springtime when you go out and smell the fresh air, it cannot be told, the*
2783 *feeling of how wonderful it is.”* (Sandor Barta, cattle herder, in Kis et al. (2016)).

2784 In this chapter, we provide an assessment of each of nature’s contributions to people (NCP) and to
2785 the quality of life of societies in Europe and Central Asia. We recognize that these contributions are
2786 diverse, reflecting the multiple societies that inhabit the region and the multiple interlinked
2787 dimensions of nature and society. For that reason, the present chapter seeks to respect and to
2788 represent the multiple values of nature’s contributions to people and to include the different
2789 knowledge systems that provide understanding of our relationship with nature.

2.1 Introduction

2.1.1 How this Chapter 2 relates to the IPBES conceptual framework

This chapter addresses the boxes of the IPBES conceptual framework “nature’s contributions to people” (NCP) and “good quality of life” and the interactions between them. Therefore, it assesses the status, trends and future dynamics of nature’s material, regulating and non-material contributions to people (IPBES, 2017b). We use the term “ecosystem services” when referring to the literature that uses this term, and “nature’s contributions to people” when synthesizing, summarizing and assessing information. This chapter also assesses the implications of changes in nature’s contributions to people for the quality of life of people in terms of instrumental and relational values (see Section 1.5.2), including food, energy and water security, health, cultural heritage, identity and stewardship, and equity (**Figure 2.1**). The chapter also examines the multiple values of nature’s contributions to people by presenting an integrated valuation, including monetary and non-monetary valuation. Assessing the link between nature’s contributions to people and quality of life requires diverse valuation methods that include market-based and non-market monetary methods as well as socio-cultural valuation methods (Jacobs et al., 2017; Pascual et al., 2017). In this chapter, we provide an assessment of nature’s contributions to people and their relationships with values and quality of life in Europe and Central Asia, bringing together scientific, technical and indigenous and local knowledge (ILK) systems.

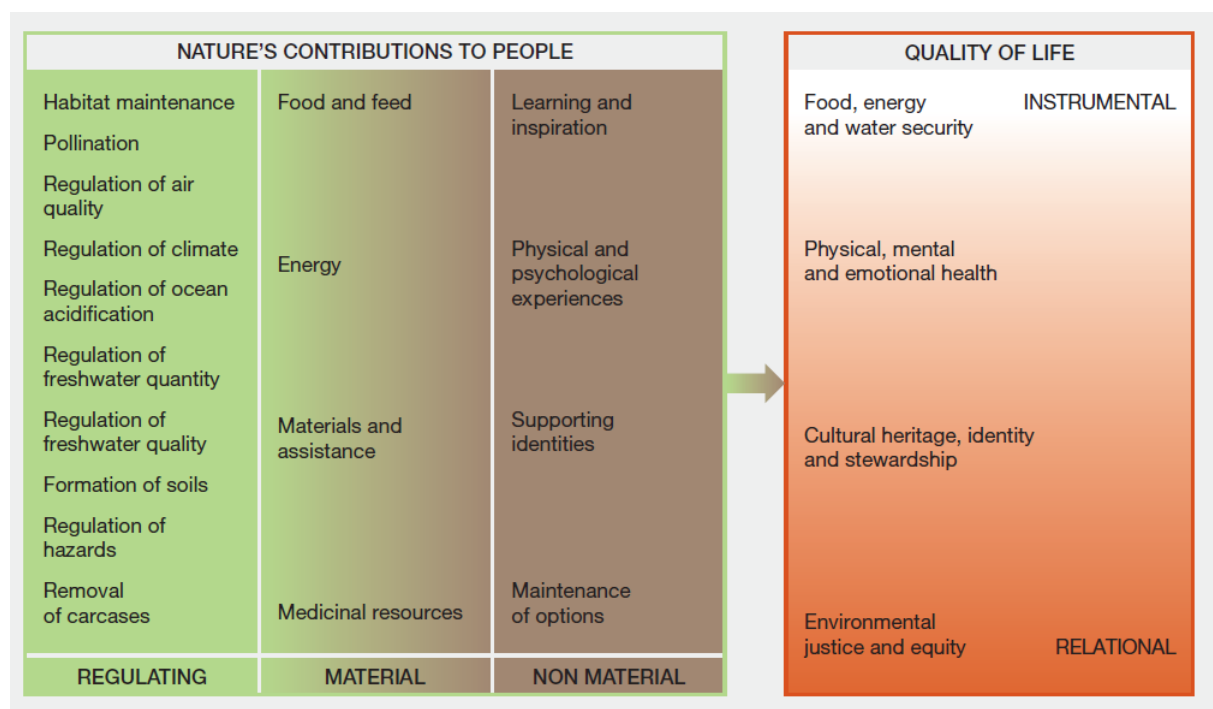


Figure 2.1: Representation of the focus of Chapter 2: status and trends of nature’s contributions to people (NCP) (Section 2.2) and their quality of life (Section 2.3) in terms of multiple values. The grading of green and brown colours indicates whether the different contributions (regulating, material and non-material) are more associated with natural or with cultural systems, respectively, and to highlight that values are intertwined with both systems.

2.1.2 Contextual dimensions of nature's contributions to people within the IPBES Regional Assessment for Europe and Central Asia

In this assessment, three generic social and ecological dimensions of nature's contributions to people are distinguished –capacity, use and value–, and different indicators assigned to them. The aim was not a systematic assessment of indicators for all dimensions, but rather to provide an overview of indicators of nature's contributions to people that relate to one of these dimensions. **Table 2.1** gives an overview of which particular dimension of nature's contributions to people is assessed in this chapter for each contribution.

The first dimension is *ecosystem service capacity* - the potential of a system to make a particular contribution to people. The second dimension is *ecosystem service use* - the actual appropriation or appreciation of nature's contributions to people by a beneficiary. The third dimension is *ecosystem service value* - the importance attached to contributions by different groups of beneficiaries. While nature's contributions to people can be valued in different ways (Jacobs et al., 2017; Pascual et al., 2017), the presence of such values determines to which elements in nature, e.g. a species, a population or an ecosystem, they are attributed.

Table 2.1: Indication of which dimension is assessed in this chapter per contributions from nature to people (ILK = indigenous and local knowledge)

	Nature's contributions to people	Ecosystem service capacity	Ecosystem service use	Ecosystem service value
1	Habitat creation and maintenance	<ul style="list-style-type: none"> Nursery capacity of habitats Surface of habitats with nursery function 	<ul style="list-style-type: none"> Breeding and overwintering areas for migratory species 	<ul style="list-style-type: none"> Non-market monetary values Non-monetary values
2	Pollination	<ul style="list-style-type: none"> Wild insect pollinators diversity and occurrence IUCN red lists status for wild pollinators Number of honey bee colonies 	<ul style="list-style-type: none"> Agriculture's dependence on pollinators % supply of honey bees relative to demand 	<ul style="list-style-type: none"> Annual market value of production that is directly linked with pollination services Non-market monetary values Non-monetary values
3	Regulation of air quality	<ul style="list-style-type: none"> Reduction in concentration of the pollutant by nature Balance between emissions and vegetation capture NO₂ and other pollutants removed by ecosystems 	<ul style="list-style-type: none"> Reduction in concentration of the pollutant Premature deaths due to air pollution Years of life lost due to air pollution 	<ul style="list-style-type: none"> Non-market monetary values Non-monetary values
4	Regulation of climate	<ul style="list-style-type: none"> Carbon storage and sequestration by different land uses Temperature decrease (reduced heat stress) 	<ul style="list-style-type: none"> CO₂ (and greenhouse gas) concentrations 	<ul style="list-style-type: none"> Non-market monetary values Non-monetary values
5	Regulation of ocean acidification	<ul style="list-style-type: none"> Marine vegetated habitats (e.g. seagrasses, kelp forests) surface and performance Rates of pelagic primary production 	<ul style="list-style-type: none"> Increases in ocean pH Existence of refugia for calcifying organisms 	
6	Regulation of freshwater quantity and flow	<ul style="list-style-type: none"> Freshwater quantity regulation Freshwater availability (for human use) Freshwater flow regulation Water retention Water regulation Stream flow, base flow 	<ul style="list-style-type: none"> Freshwater extraction Surface water extraction Freshwater use 	<ul style="list-style-type: none"> Non-market monetary values Non-monetary values
7	Regulation of freshwater quality	<ul style="list-style-type: none"> Surface of floodplains and wetlands Ecological status of water bodies Nitrate removal rate in a river 	<ul style="list-style-type: none"> Concentration of nitrogen and phosphorous in inland freshwater ecosystems Quality of drinking water and bathing water 	<ul style="list-style-type: none"> Non-market monetary value Non-monetary values

			<ul style="list-style-type: none"> • Winter means of dissolved inorganic nitrogen (nitrate + nitrite + ammonium), oxidized nitrogen (nitrate + nitrite) and phosphate concentrations in seas 	
8	Formation and protection of soils	<ul style="list-style-type: none"> • Capacity of ecosystems to avoid erosion: C factor of USLE erosion model • Soil fertility • Maintenance of soil structure • Soil organic carbon content • Available nutrients, available organic contaminants 	<ul style="list-style-type: none"> • Erosion rates 	<ul style="list-style-type: none"> • Non-market monetary value • Non-monetary values
9	Regulation of hazards and extreme events	<ul style="list-style-type: none"> • Habitats designated for flood protection • Flood mitigation capacity of wetlands • Flood regulation 	<ul style="list-style-type: none"> • Number and intensity of coastal and fluvial flood events • Damage caused by flood events 	<ul style="list-style-type: none"> • Non-market monetary value • Non-monetary values
10	Removal of carcasses	<ul style="list-style-type: none"> • IUCN red lists status for vertebrate scavengers • Population trends of vertebrate scavengers 	<ul style="list-style-type: none"> • Amount of animal and livestock carcasses removed by vertebrate scavengers • Emissions of CO₂ resulted by the substitution of natural scavenging with artificial removal of carcasses 	<ul style="list-style-type: none"> • Avoided costs • Non-market monetary value
11	Food and feed	<ul style="list-style-type: none"> • Agriculture area per capita • Cultivated area per agricultural population • Organic agricultural area 	<ul style="list-style-type: none"> • Production of cereals, fruit, vegetables, maize • Production of crops processed: olive oil, rapeseed oil, sunflower oil, wine • Livestock primary production: eggs, meat, milk • Marine wild capture seafood • Inland wild fish captures • Aquaculture production 	<ul style="list-style-type: none"> • Market values • Non-market monetary value • Non-monetary values
12	Energy		<ul style="list-style-type: none"> • Woodfuel production stocks • Annual production of biofuel • Biodiesel and ethanol production • Woodfuel consumption stocks • Trade balance of biofuels • Trade balance of biodiesel and ethanol 	<ul style="list-style-type: none"> • Market value of woodfuel • Non-market monetary value • Non-monetary values
13	Materials and assistance	<ul style="list-style-type: none"> • Density of timber stocks • Surface of cork oak forests • Status of mearl bed habitats 	<ul style="list-style-type: none"> • Production of roundwood • Production of cotton • Cork harvested • Production of turpentine, resin and rosins • Production of kelp • Extraction of maerl 	<ul style="list-style-type: none"> • Market value of some materials • Non-market monetary value • Non-monetary values
14	Medicinal, biochemical and genetic resources	<ul style="list-style-type: none"> • Number of medicinal plants • Endangered status of medicinal plants 	<ul style="list-style-type: none"> • Use of medicinal plants 	<ul style="list-style-type: none"> • Non-market monetary value of genetic resources • Non-monetary values
15	Learning and inspiration	<ul style="list-style-type: none"> • Protected areas and outdoor spaces used for learning 	<ul style="list-style-type: none"> • Linguistic Diversity Index • Level of endangerment of languages • Transmission of indigenous and local knowledge 	<ul style="list-style-type: none"> • Non-market monetary value • Non-monetary values
16	Physical and psychological experiences	<ul style="list-style-type: none"> • Surface of Protected Areas • Recreational potential index • Percentage of forest area designated or managed for recreation purposes • Richness of species collected for wild food or hunted 	<ul style="list-style-type: none"> • Nature as the main reason for going on holidays • Number of marine and freshwater anglers • Participant rates (%) in nature-based recreation activities 	<ul style="list-style-type: none"> • Market value of mushrooms • Market value of berries • Non-market monetary value • Non-monetary values

17	Supporting Identities	<ul style="list-style-type: none"> Protected Areas (IUCN categories Ia Strict Nature Reserve, Ib Wilderness Area, II National Park and IV Habitat/species management area) Sacred Natural Sites per country Forest area primarily designated or managed for spiritual or cultural values (Food and Agriculture Organization of the United Nations) 	<ul style="list-style-type: none"> Species appearance in news articles Attitudes towards nature preservation 	<ul style="list-style-type: none"> Non-market monetary value Non-monetary values
18	Maintenance of options	<ul style="list-style-type: none"> Total number of endemic species Phylogenetic diversity 	<ul style="list-style-type: none"> Use of genetic diversity by pharmaceutical companies Recent and unanticipated benefits from biodiversity 	<ul style="list-style-type: none"> Avoided costs of unanticipated benefits from biodiversity

2.2 Status and trends of nature's contributions to people in Europe and Central Asia

This section assesses the status (from 2011 to 2016) and trends (from 1950) of nature's contributions to people in Europe and Central Asia based on a systematic literature review conducted in three main stages: (i) generation of search strings (see electronic Appendix 2.1); (ii) systematic search of primarily published peer-reviewed scientific articles, grey literature and indigenous and local knowledge; and (iii) the extraction of information from 25 relevant papers per contribution in each subregion of Europe and Central Asia. The assessment also included indicators available at regional and subregional levels and indigenous and local knowledge derived from a Europe and Central Asia "ILK dialogue workshop" held in January 2016 in Paris (Roue & Molnar, 2016) (see electronic Appendix 2.2). We report on the general status and trends in Europe and Central Asia and in its subregions of Western, Central and Eastern Europe, and Central Asia; however, a detailed list of references can be found in electronic Appendix 2.3.

It is important to point out that, across the region, there are many examples where indigenous and local knowledge is essential for preserving nature's contributions to people, for example in the case of transhumance shepherds (see **Box 2.1**). Other examples of the relevance of indigenous and local knowledge to the maintenance of nature's contributions to people, such as pollination, habitat maintenance, food and feed, medicinal resources and physical and psychological experiences are those derived from the management of cultural landscapes, such as "dehesas", "montados" or "bocages" (**Box 2.1**).

Box 2.1: The role of indigenous and local knowledge of transhumance shepherds for preserving some of nature's contributions to people

Transhumance is a traditional farming practice of moving livestock from one grazing ground to another in a seasonal cycle. It is based on indigenous and local knowledge that has proven to be a determinant for the provision of nature's regulating contributions to people (seed dispersal, fire prevention or soil fertility), as well as nature's material and non-material contributions to people, such food, wood, ecotourism or local identity (Oteros-Rozas et al., 2013a; Oteros-Rozas et al., 2014). The use, conservation and transmission of transhumance-related local knowledge has been shown to be mostly linked with the practice of transhumance on foot. Transhumance on foot would not be possible without ancestral knowledge and collaborative practices. Drove roads, maintained for and by transhumant shepherds through the migration of their herds, are biodiversity reservoirs (Azcarate et al., 2013) as well as corridors contributing to landscape connectivity (Galvin, 2008). Seeds

can be dispersed along hundreds of kilometres by transhumant sheep on their migration (Manzano & Malo, 2006).

In Spanish “dehesas” (open woodlands resulting from the clearing of original evergreen oak woodland and shrubland areas), shepherds’ seasonal management of grasslands allows for holm oak regeneration in a context where tree ageing is a major challenge for biodiversity conservation and overall sustainability (Carmona et al., 2013). Fire prevention, as a result of livestock consumption of flammable biomass has also been tightly linked with transhumance management (Oteros-Rozas et al., 2013a; Zumbunnen et al., 2012). The customary practice of “redileo” and the enclosure of animals in changing resting areas along the drove roads, contribute to soil fertility (Oteros-Rozas et al., 2012).

End of Box 2.1

2.2.1 Status and trends of nature’s regulating contributions to people

2.2.1.1 Habitat creation and maintenance

2.2.1.1.1 Nurseries

Habitat as a nursery for juveniles of a particular species refers to where “its contribution per unit area to the production of individuals that recruit to adult populations is greater, on average, than production from other habitats in which juveniles occur” (Beck et al., 2001). An overview of the nursery function as a contribution from nature to people is provided by Lique et al. (2016) who conclude that it is a concrete benefit to people, especially through food provision or recreation. For example, a positive effect has been demonstrated between the presence of nursery habitat and fish stocks of sole (*Solea solea*) in the Seine estuary in France (Cordier et al., 2011). The importance of conserving nursery areas has also been demonstrated for commercially important invertebrate species, such as queen scallops (*Aequipecten opercularis*), soft-shell clam (*Mya arenaria*) and sea urchin (*Psammechinus miliaris*). The importance of nursery habitat for juveniles is also relevant in the cases of maerl grounds, kelp forests, *Cystoseira* forests, seagrass meadows and reefs, among others.

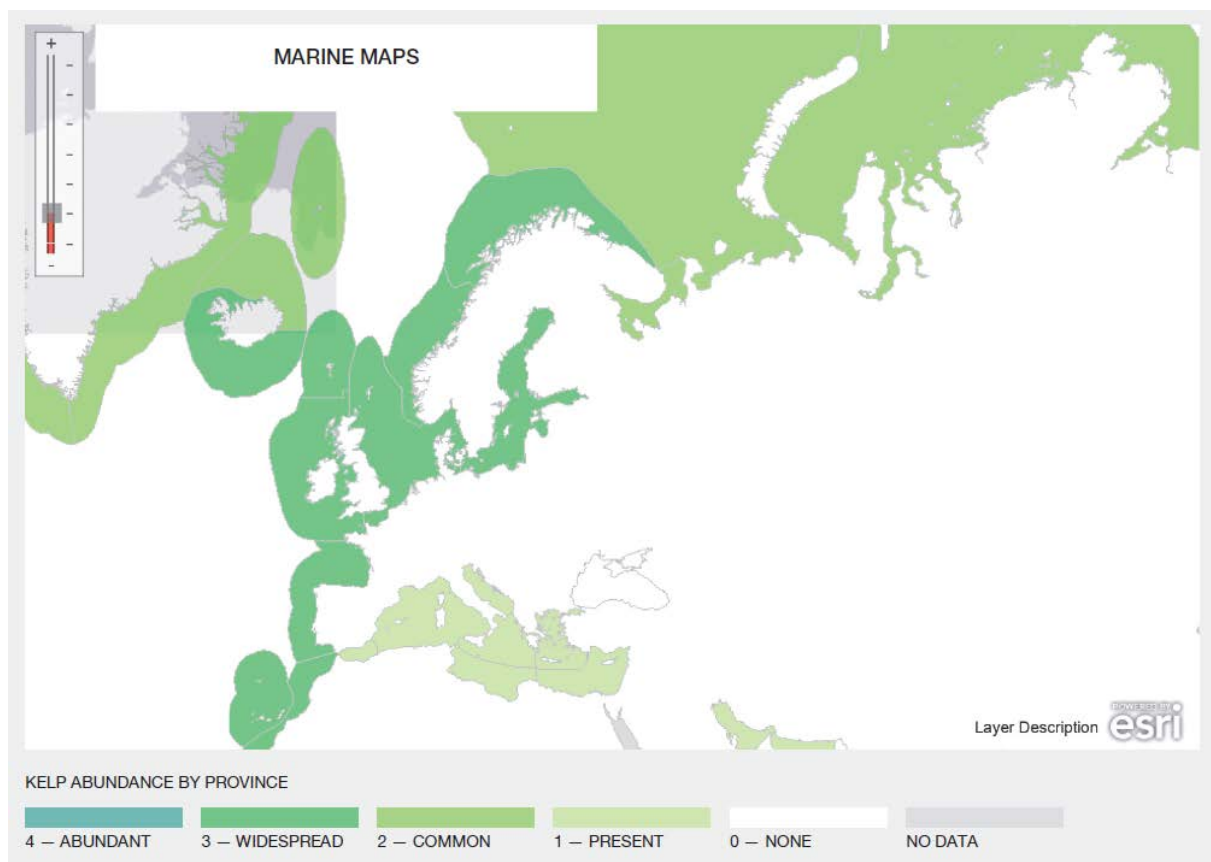
Maerl beds harbour significantly higher numbers of juveniles of these species than impacted areas (Kamenos et al., 2004). However, maerl beds have been undergoing a decline in condition and extent across most of their range in European Union (Hall-Spencer et al., 2008; JNCC, 2007; OSPAR, 2010), mainly due to commercial extraction (see Section 2.2.2.3), as well as negative impacts of mussel farming, dredging for scallops and bivalves, aquaculture and eutrophication (Grall & Hall-Spencer, 2003; Hall-Spencer & Bamber, 2007; Hall-Spencer et al., 2008; JNCC, 2007).

In the European Union marine environment, kelp forests also provide important habitat for a wide range of species (Araújo et al., 2016; Smale et al., 2013), including commercially important ones such as European lobster (*Homarus gammarus*). They also act as nurseries for invertebrates and fish, such as Atlantic cod (*Gadus morhua*), as well as key mating and feeding grounds for many North Atlantic fish species, such as Ballan Wrasse (*Labrus bergylta*) and Goldsinny Wrasse (*Ctenolabrus rupestris*) (Bertocci et al., 2015; Casal et al., 2011; Smale et al., 2013). While knowledge gaps exist in terms of demonstrating the actual effect of kelp forest abundance and density on associated fisheries, most studies show a positive kelp-fisheries relationship (Bertocci et al., 2015). Recent studies show a dominant decreasing trend in kelp forest distribution and abundance across parts of Western, Central and Eastern Europe due to global warming, sea urchin grazing, harvesting, pollution and fishing pressure (see **Figure 2.2**) (Araújo et al., 2016; Casal et al., 2011). Distribution and abundance of some kelp species is predicted to further change in response to ocean warming in the Atlantic (see **Table 2.2**) (Smale et al., 2013) (see Section 2.2.1.5).

2907 **Table 2.2: Kelp species in UK and Irish waters and their predicted change in abundance or range of**
 2908 **each species in response to continued environmental change. Source: (Smale et al., 2013)**

Species	Distribution	Depth range (m)	Length (m)	Lifespan (years)	Predicted change
<i>Laminaria hyperborea</i>	Arctic-Portugal	0-30	1-3	5-18	Decrease
<i>Laminaria digitata</i>	Arctic-France	0-15	1-2	4-6	Decrease
<i>Laminaria ochroleuca</i>	UK-Morocco	0-30	1-3	5-18	Increase
<i>Saccharina latissima</i>	Arctic-France	0-30	1-3	2-4	Decrease
<i>Alaria esculenta</i>	Arctic-France	0-35	1-2	4-7	Decrease
<i>Saccorhiza polyschides</i> ¹¹	Norway-Morocco	0-35	2-3	1	Increase
<i>Undaria pinnatifida</i>	Global NIS	0-15	1-3	1	Increase

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¹¹ *S. polyschides* is not a true kelp of the order Laminariales (being of the order Tilopteridales), but is included as this “pseudokelp” can perform a similar ecological role as the dominant canopy former.

Figure 2.2: Kelp abundance in parts of Western, Central and Eastern Europe (The Nature Conservancy, n.d.)

Cystoseira brown algae also provide biogenic structure, food and shelter for many organisms including fish. These habitats have, however, been declining or disappearing throughout the Mediterranean Sea due to a decrease in water quality and building development on the coast (Cheminée et al., 2013; Mangialajo et al., 2013). In Corsica, the depletion of large and continuous forests of *C. balearica* with a surface area of more than 2500 m² could result in a significant loss of Wrasse (*Symphodus spp.*) juveniles, which are dependent on this habitat (Cheminée et al., 2013).

Also in the Mediterranean Sea, many commercial fish species rely on seagrass beds which provide permanent habitat, allowing full life cycle completion and providing temporary nurseries for juvenile development, feeding areas for various life cycle stages and refuge from predation (Jackson et al., 2001). Eelgrass (*Zostera marina*) meadows play a similar role in the Baltic and North Atlantic (Boström et al., 2014). Seagrasses have declined worldwide and particularly in the Mediterranean, Baltic and Atlantic Seas, with negative consequences for the provision of nursery habitats (Boström et al., 2014; McCloskey & Unsworth, 2015; Waycott et al., 2009).

Biogenic reefs, i.e. reefs where structure is created by the animals themselves, are also important fish habitats, as their complex structures provide refuge for fish and substrate for benthic fauna and macroalgal forests which, in turn, provide refuge and feeding areas for fish species (Støttrup et al., 2014). A positive relationship between reef habitats and fish species abundance was demonstrated by a study on reef restoration in Denmark on the example of commercially important species cod and saithe (Støttrup et al., 2014). Many biogenic reef habitats on the European coasts of the Atlantic Ocean and the North Sea have been in decline due to various anthropogenic pressures (OSPAR, 2010).

Other nursery and spawning habitats have also been reported in national assessments. For example, in Finland the most important nursery habitats include bladderwrack (*Fucus vesiculosus*) and common eelgrass (*Zostera marina*) meadows for fish species, wooded mires for many forest grouse species and spawning rivers for salmon (Boström et al., 2014; Jäppinen & Heliölä, 2015). The state of Atlantic salmon (*Salmo salar*) spawning rivers in the Baltic Sea has also been assessed by the Helsinki Commission, showing that the number of salmon spawners had increased since the mid-1990s in some rivers of the Bothnian Bay (ICES, 2013).

2.2.1.1.2 Breeding and overwintering areas for migratory species

A number of scientific publications discuss population declines in a range of migratory species, including migratory birds of Western, Central and Eastern Europe (Berthold et al., 1998; Sanderson et al., 2006). This includes European breeding birds wintering in Sub-Saharan Africa (Sanderson et al., 2006). Over half (50.4%) of fully migratory species were reported to be in decline between 1990 and 2000, falling, however, to 35.7% between 2000 and 2012 (Gilroy et al., 2016). Despite this decline in wintering populations, overall waterbirds show an increasing trend in the European Union, being higher for those listed on Annex I of the Birds Directive (**Figure 2.3**) (Wetlands International European Association, 2015).

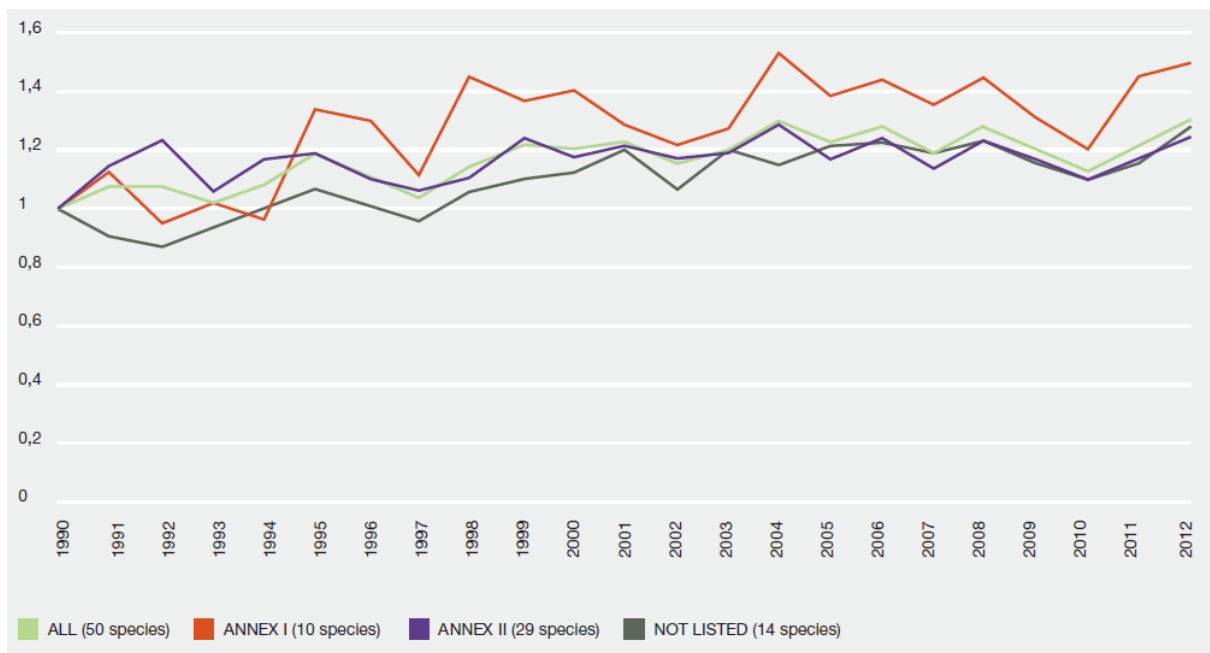


Figure 2.3: Trends in wintering populations of 50 waterbird species in the European Union according to their status on the Birds Directive (Wetlands International European Association, 2015).

2.2.1.2 Pollination

Pollination by animals plays a vital role as a regulating contribution from nature to people with the majority of wild flowering plant species (Ollerton et al., 2011) and crop types (Klein et al., 2007) benefitting from it, at least in part. Both wild and managed pollinators play significant roles in crop pollination, and crop yield or quality depend on both the abundance and diversity of pollinators (IPBES, 2016a). Pollinator diversity contributes to crop pollination even when managed species are abundant, and a diverse community of pollinators generally provides more effective and stable crop pollination than any single species.

Pollinators provide a wide range of material contributions, such as the food, fibre, building materials, medicines and other products derived from pollinator-dependent plants (see Section 2.2.2). Other products are directly produced by some species of bees such as honey, pollen, wax, propolis, resin, royal jelly and bee venom (IPBES, 2016a). These are important for nutrition, health, medicine, cosmetics, religion and cultural identity and so contribute to a good quality of life (IPBES, 2016a).

Since the 1950s wild insect pollinators in Europe and Central Asia have declined in diversity and occurrence, and also in abundance for some taxa where data are available (see Chapter 3). IUCN Red Lists for continental Europe (here extending from Iceland in the west to the Urals in the east) show that 37% of bee and 31% of butterfly species have declining populations (excluding data deficient species) and 9% of both taxa are classified as threatened (European Commission, 2014a; Van Swaay et al., 2010). Severe losses of managed colonies of the western honey bee have been reported in many Western European countries and former-USSR countries since 1961 (Aizen & Harder, 2009).

Agriculture in Europe and Central Asia has become more pollinator dependent since 1961, with Mediterranean and Central Asian countries being the most reliant on pollination services for crop production, due to the substantial production of highly pollinator-dependent fruits (see **Figure 2.4**). The potential capacity of managed honey bees in Western, Central and Eastern Europe to supply pollination services to pollinator-dependent crops is insufficient to meet demand in many countries

and the shortfall has increased between 2005 and 2010 because of changes in crop markets (see **Figure 2.5**; Breeze et al. (2014)). This suggests a high and increasing reliance on wild insects for crop pollination services. Without a systematic monitoring scheme, however, it is not possible to accurately assess the importance of wild pollinators at a local scale (e.g. April et al. (2016)). Although some attempts have been made to model available pollinator natural capital (e.g. Schulp et al. (2014a)), to date they have not considered pollinator behaviour. More suitable models have been developed (Olsson et al., 2015; Ricketts & Lonsdorf, 2013) but have not yet been applied beyond case study or hypothetical sites. In addition, a variety of indicators have been used for mapping pollination, however, almost all are based on very indirect (e.g. land cover variables) or relative measures of pollination and lack empirical validation of reliable representation of pollination delivery.

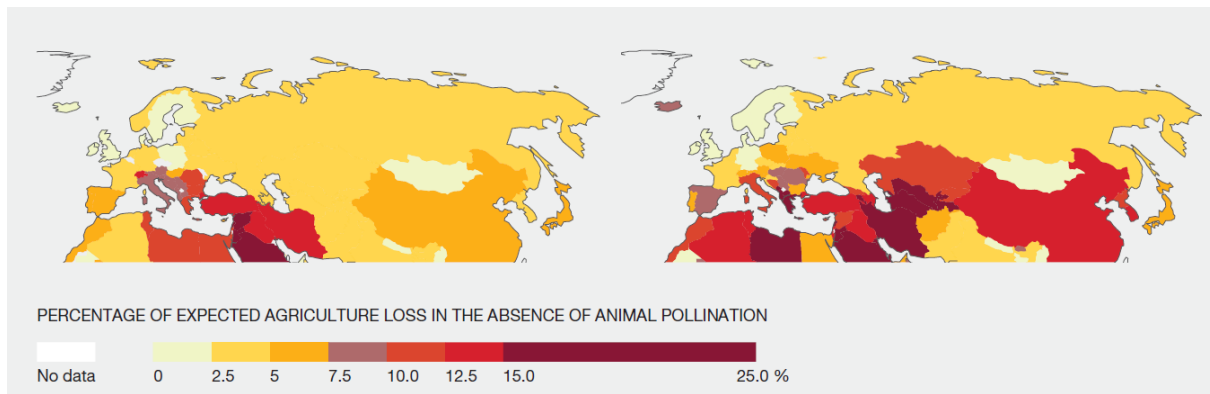


Figure 2.4: Agriculture's dependence on pollinators (i.e., the percentage of expected agriculture production volume loss in the absence of animal pollination (categories depicted in the coloured bar) in 1961 (right) and 2012 (left) (FAO, 2017) and following the methodology of Aizen et al. (2009).

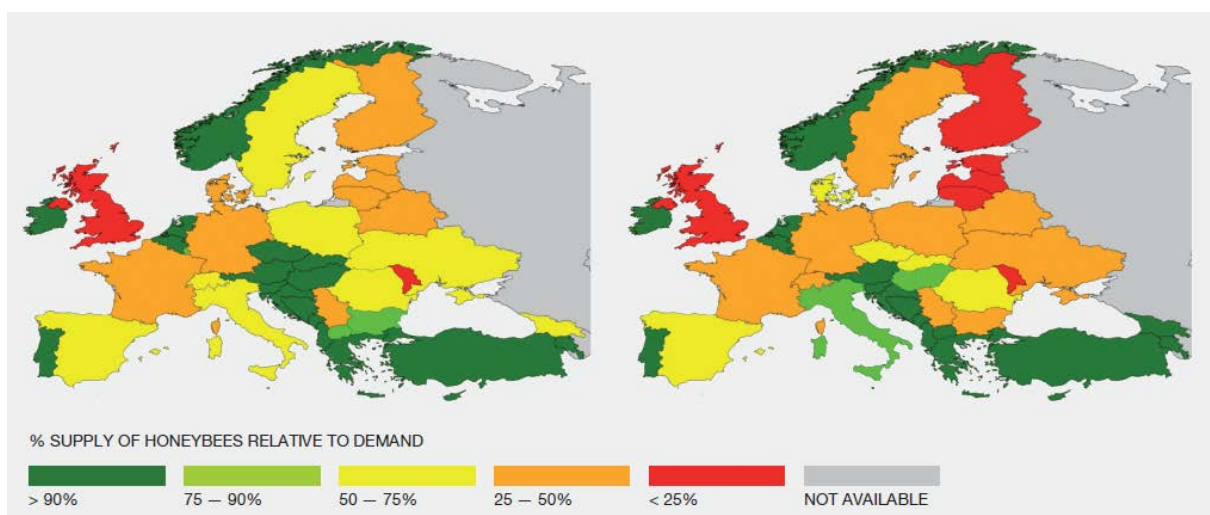


Figure 2.5: A comparison of the pollination service capacity of honey bees in 2005 (left) and 2010 (right) in Western Europe (except Israel), Central Europe and parts of Eastern Europe (Breeze et al., 2014).

Pollination contributes to a *good quality of life* through: the role of pollinators underpinning the productivity of many of the world's crops which contribute to healthy diets; beekeeping, pollinator-dependent plant products and honey which support livelihoods; and pollinator-dependent landscapes which help provide a rich and meaningful cultural and spiritual life (IPBES, 2016b). Throughout Europe

and Central Asia there has been a 14% increase in honey production (from 314,874 to 358,191 tonnes per year) between 1992 and 2012. This change has, however, been uneven between regions, presenting a decline of 27% in Western Europe and 63% in Central Asia, while an increase of 29% in Eastern Europe and 31% in northern Central Europe (FAO, 2017). In addition to honey and other direct calorific value of products derived from pollinator-dependent food crops, these products also benefit human health via supply a major proportion of micronutrients such as vitamin A, Iron and Folate; the fractional dependency of these micronutrient production on pollination is particularly high in southern areas of Western and Central Europe (Chaplin-kramer et al., 2014).

2.2.1.3 Regulation of air quality

The regulation of air quality by ecosystems is complex, depending on the atmospheric pollutant in question, emission levels, scale, and ecosystem characteristics. The contribution of vegetation varies according to multiple plant factors including species, leaf area, height, presence of wax or hair, evergreen versus deciduous lifeform and surface roughness. This needs to be balanced against their pollution resilience, as well as their potential to decrease air quality by trapping pollutants, emitting gases including biogenic volatile organic compounds (BVOC) and methane (Janhäll, 2015; Sæbø et al., 2012), and producing allergens (Asam et al., 2015). In many countries, greenhouse gas emissions are decreasing as countries seek to comply with commitments (EEA, 2015a) and the European Union Air Quality Directive (Directive 2008/50/EC)¹², but trends in air quality regulation by ecosystems vary according to the balance between emissions and capture by vegetation. Between 2000 and 2010, in the European Union, nitrogen dioxide (NO₂) removal by urban green areas increased by 0.8% (European Commission, 2015b). In Spain air quality has slightly decreased overall, but air quality regulation by forests improved between 1960 and 2010 as forest area increased due to land abandonment, with mountain areas showing mixed trends of forest area and rivers, lakes and wetlands showing decreases of forest area (Spanish National Ecosystem Assessment, 2013).

Three aspects of the regulation of air quality by ecosystems are briefly reviewed here: (i) the broad contribution of different ecosystems; (ii) the impacts of parks and trees at the local scale in cities; and (iii) ecosystem contributions to emissions. Forests and trees are particularly important at both the regional and local level, especially in cities, for capturing pollutants through both wet and dry deposition. A simple estimation of air pollution capture and removal, based only on dry deposition velocity¹³ (as a measure of capacity of removal by vegetation) shows that for nitrogen oxides (NO_x), mountains with forests and natural grassland have a high capacity (primarily due to the higher level of pollutant capture by forests), while forests in Sweden and Finland and vegetation in parts of Central and Western Europe have intermediate capacity (**Figure 2.6a**). When combined with local pollution concentrations in urban and peri-urban areas, it shows that trees in southern Scandinavia and parts of Central and Southern Western Europe are particularly important (**Figure 2.6b**). However, this can vary according to factors including pollutant (type and emission level), topography and location. For example, in Limburg Province, Netherlands, the vertical capture of PM₁₀¹⁴ (mean kg km⁻² yr⁻¹) was estimated as: heath 2056, forest 2001, peat 968, cropland 956 and urban 535 (Remme et al., 2014), with heaths capturing more than forests, as they are closer to the emission sources.

¹² <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0050>

¹³ rate of deposition of particles and gases (in this case) on vegetation

¹⁴ PM10 is particulate matter 2.5 to 10 micrometers in diameter

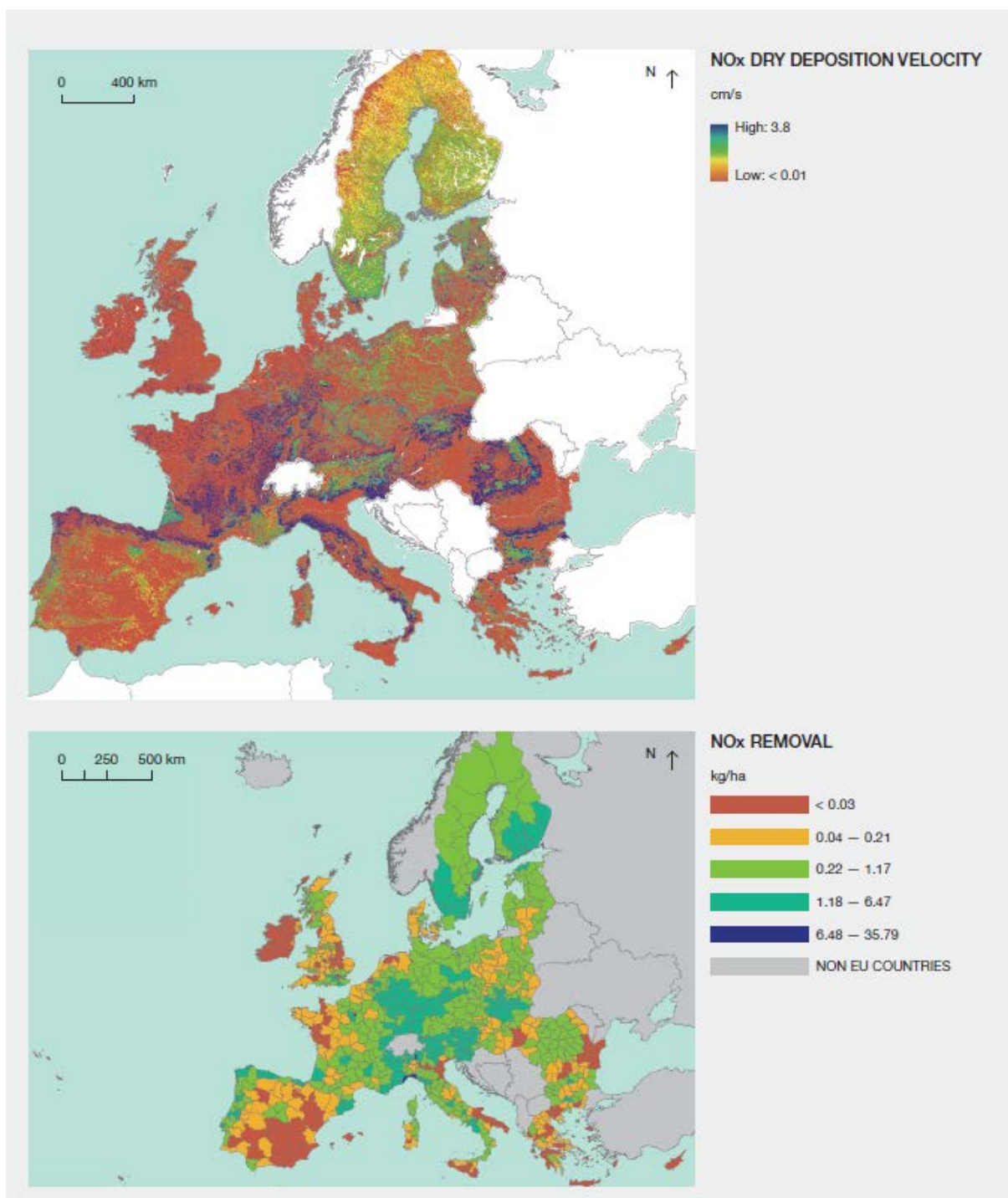


Figure 2.6: Top: Velocity of dry deposition of nitrogen oxides in cm/sec in parts of Western and Central Europe (European Commission, 2011); Bottom: Removal of nitrogen oxides (kg/ha) by trees in urban and peri-urban areas (European Commission, 2011).

The total net benefit of vegetation in cities for capturing pollutants can be small relative to total emissions. For example, urban forests in Barcelona in 2008 removed 305.6t of air pollutants and 19,036 t CO₂eq, representing 2.66 % of PM₁₀ (particulate matter 10 micrometers or less in diameter), 0.43 % of NO₂, and 0.47 % of CO₂eq of emissions (Baró et al., 2014). The tree canopy in Greater London is estimated to remove between 0.7% and 1.4% of PM₁₀ from the urban boundary layer (Tallis et al., 2011). Measurements of NO₂, anthropogenic volatile organic compounds (VOCs) and particle

deposition in two Finnish cities suggest that urban vegetation removes little pollution in northern areas (Setälä et al., 2013). Nevertheless, the amounts locally removed can be very important.

Several studies demonstrating the removal of different pollutants by trees or parks in cities of the European Union show similar patterns, although quantitative results are mostly not directly comparable since the studies use different units. Studies of different Italian cities showed that generally evergreen broadleaved forests capture more ozone (O₃) than coniferous forest, followed by mixed broadleaved and coniferous forest, with deciduous broadleaved forest capturing the least (e.g. Bottalico et al. (2016); Manes et al. (2016)). For PM₁₀ the sequence decreases from mixed broadleaved and coniferous forest, to coniferous forest, evergreen broadleaved forest and deciduous broadleaved forest (Manes et al., 2016). Seasonal differences include deciduous trees capturing more PM₁₀ and O₃ in summer when in leaf (e.g. (Manes et al., 2016; Marando et al., 2016)), while evergreens captured more in autumn and winter (Marando et al., 2016). Research on European urban trees found that *Quercus* and *Platanus spp.* have the highest PM removal efficiency (Grote et al., 2016). Thus, the selection of species planted can affect air quality regulation. In cities, trees can also reduce the dispersion of pollutants, leading to increased local concentrations (Janhäll, 2015).

Ecosystems can be sources or precursors of gases, which affect air quality. For example ammonia and methane are involved in the photochemical formation of O₃, with agricultural fertilizer application and livestock contributing to ammonia emissions and livestock and wetlands to methane emissions (Kayranli et al., 2010). Trees can emit biogenic volatile organic compounds (BVOCs), especially isoprenes, as well as allergens such as pollen (Grote et al., 2016). Modelling of BVOC emissions shows particularly high levels in parts of southern parts of Western Europe due to a combination of species and high temperatures, while in Scandinavia it is a result of the forest cover (**Figure 2.7**). Air pollution can also indirectly affect ecosystems, through soil and water acidification, eutrophication, or crop and vegetation damage from O₃ (EEA, 2016a), which all can reduce the ability of ecosystems to cope with particulate and gaseous pollutants. For example, in forests the critical O₃ level (20 000 µg/m³/h during the summer season) was exceeded in 2013 in 66% of the 33 member countries of the European Environment Agency (EEA) (except in Turkey), with more northern countries in that area falling below this level, while in southern parts of Western Europe the critical level may be exceeded by a factor of four or five (EEA, 2016a).

Air quality impacts quality of life, especially human health in cities (Queenan, 2017). For example, for 40 countries of Western and Central Europe in 2012, exposure to PM_{2.5}¹⁵, O₃ and NO₂ was responsible for 432,000, 75,000 and 17,000 premature deaths, respectively. The highest rates of years of life lost per 100,000 inhabitants due to PM_{2.5} were in Central and Eastern European countries, and for O₃ the Western Balkans, Hungary and Italy (EEA, 2015a). Its direct and indirect impacts on processes, such as eutrophication and acidification, affect ecosystem health and species composition (Jones et al., 2014), which can influence their ability to supply other contributions from nature to people.

¹⁵ PM_{2.5} is particulate matter 2.5 micrometers or less in diameter

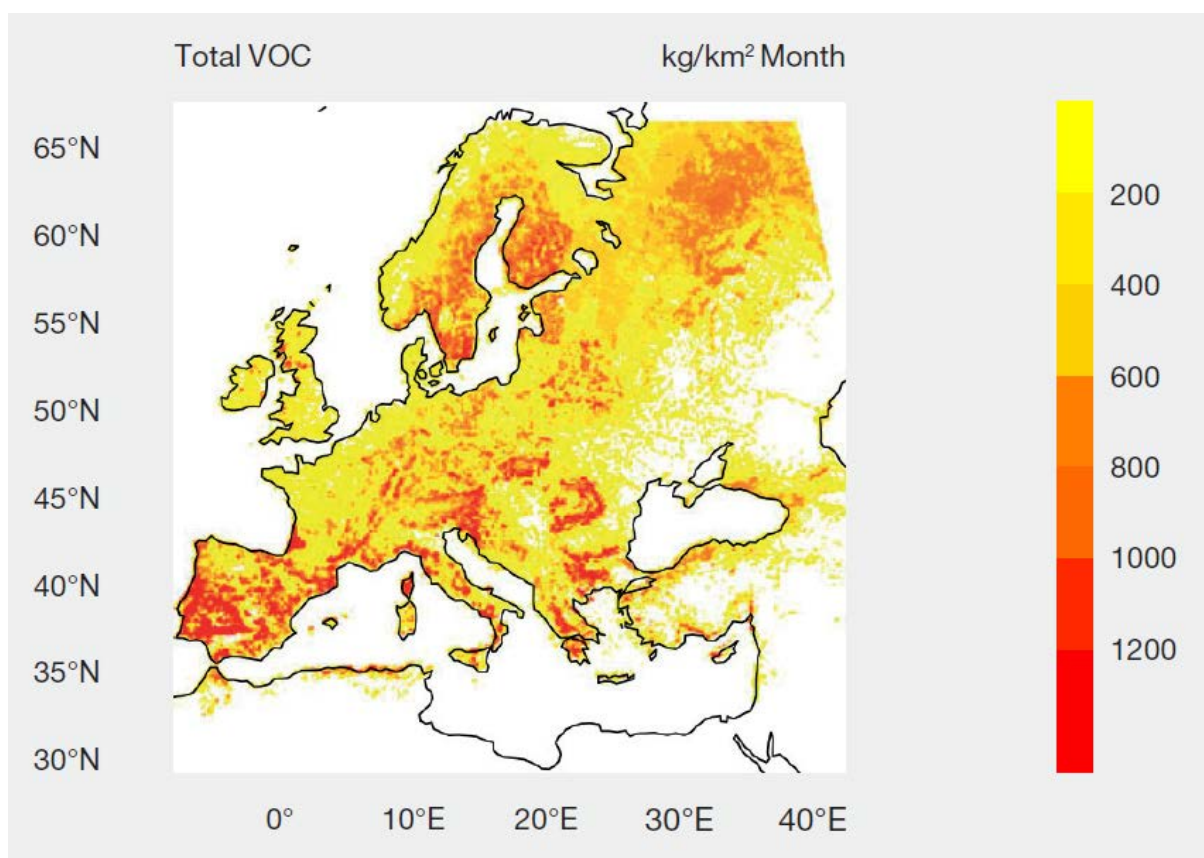


Figure 2.7: Modelled emissions of biogenic volatile organic compounds (VOC) from terrestrial vegetation in the western parts of Europe and Central Asia in 2000 (Steinbrecher et al., 2009).

2.2.1.4 Regulation of climate

Ecosystems are important in climate regulation as they affect greenhouse gas fluxes, contributing both to emissions and storage, which could enhance climate warming or climate mitigation, respectively. Nearly all countries in Europe and Central Asia have submitted “intended nationally determined contributions” under the Paris Agreement, with ecosystems playing a role in their mitigation plans. Ecosystems can also influence heat transfers by reflecting or absorbing incoming solar radiation and moisture transfers through modifying water flows and evapotranspiration, as well as affecting microclimate, primarily through reducing temperature extremes (Edmondson et al., 2016).

There is considerable uncertainty about the changes in carbon flux and balance. It has been estimated that, between 1950 and 2007, increased carbon biomass stocks in Europe’s forests represented 10% of the EU-15¹⁶ cumulated fossil fuel emissions (Ciais et al., 2008), while between 1990 and 2012 there was a net decrease in greenhouse gas emissions from land use, land-use change and forestry (LULUCF) changes due to increased carbon storage (**Figure 2.8**), primarily as a result of increases in forest area, with 87% of the positive balance coming from Eastern Europe, 19% from Central Europe and 9% from Western Europe. It has been estimated, based on models and observations, that in continental Europe between 2000 and 2005, the balance of greenhouse gases was $-29 \pm 194 \text{ TgC yr}^{-1}$ for croplands, forests and grasslands, as CO_2 taken up mostly by forests and grasslands nearly balanced CH_4 and N_2O emissions (mostly from cropland), while for the 25 member States of the European Union at that stage

¹⁶ Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom

the balance showed emissions of $34 \pm 99 \text{ TgC yr}^{-1}$ (Schulze et al., 2009). In Central Asia, net removals of greenhouse gases by land use, land-use change and forestry (LULUCF) between 1992 and 2012 increased from -5.3 to -25.1 $\text{Tg CO}_2\text{eq}$ (FAO, 2017), mostly due to increased area of grasslands.

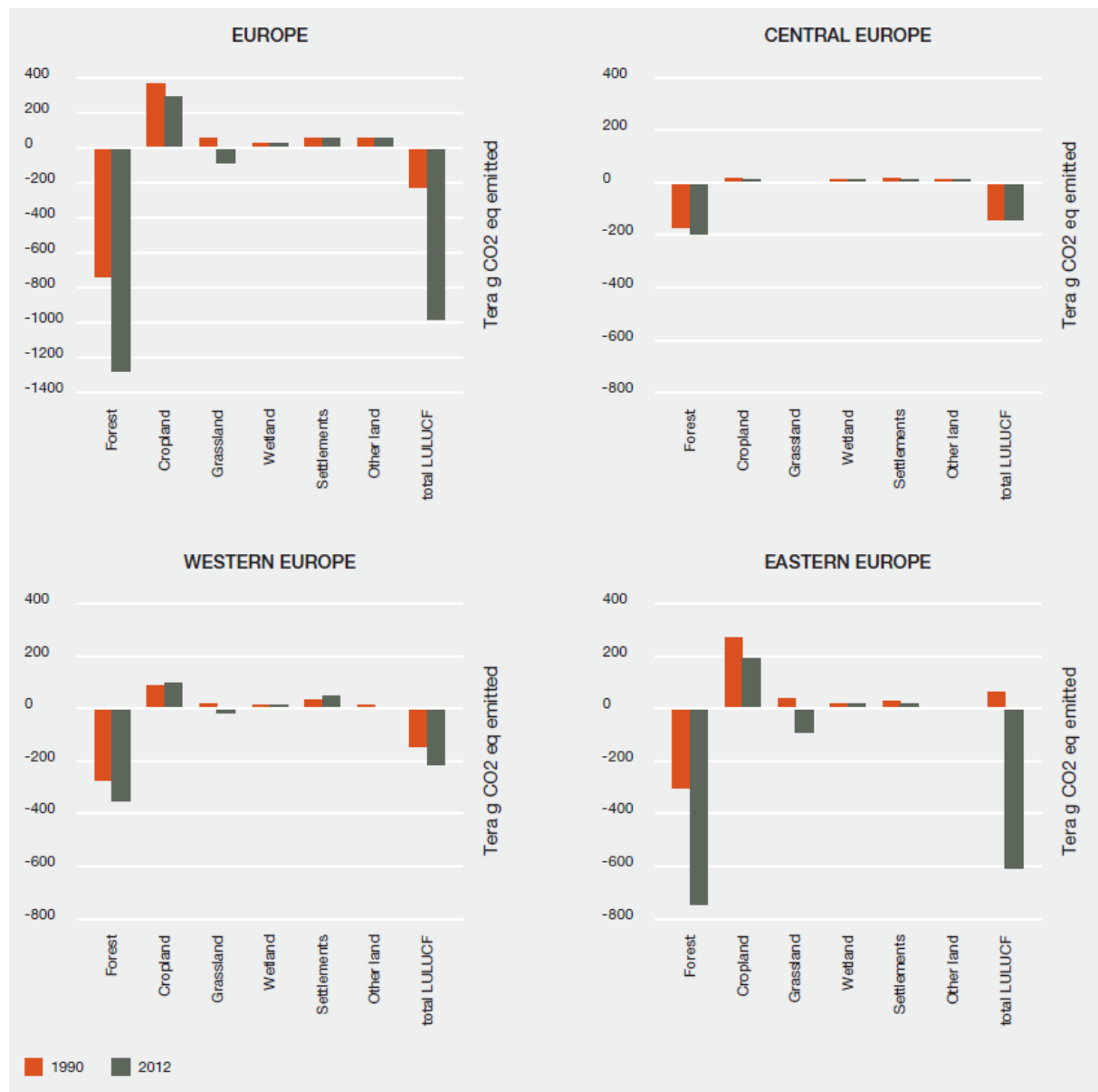


Figure 2.8: Net annual greenhouse gas emissions and removals for the land use, land-use change and forestry (LULUCF) sector (1990-2012) for Western, Central and Eastern Europe in TgCO_2 equivalent based on reporting by the United Nations Framework Convention on Climate Change (UNFCCC, 2014). Central Asia countries are not included as they have not reported for the entire period. Note that the y-axis for Europe has a different scale.

Net increases in emissions and decreases in carbon storage could have several causes, including wetland drainage, loss of wetlands and forests due to urban expansion, agricultural intensification, other land use changes, and emissions from northern peatlands due to climate change. In nearly all countries of Europe and Central Asia, forests are the most important net carbon sink and carbon stocks in living forest biomass between 1990 and 2015 were increasing or stable (see **Figure 2.9**). For some countries, however, wetlands can be more important in regulating climate but, given the decrease in wetland area in many parts of continental Europe (Dixon et al., 2016; EEA, 2016c) (see Section 2.2.1.6),

they may not be able to maintain this contribution from nature to people into the future. In Russia, vegetation (primarily boreal forests and peatlands) and soils hold 16% (336 Gt) of the world's carbon stores, with soils making the greater contribution. With climate change, the tundra zone could become a net emitter, especially of methane (Bukvareva et al., 2015).

In Europe and Central Asia, soils represent a large carbon stock (Jones et al., 2012; Schulze et al., 2010), but the storage capacity varies depending on land use and soil type. Peat soils are undergoing major carbon losses due to drainage and cultivation (Akker et al., 2016). Cropland soil organic carbon is also declining in many areas of Europe and Central Asia (see Section 2.2.1.7), but agricultural soils represent a large potential sink if appropriate management practices are applied (Lugato et al., 2014). Figures vary for the area of cropland abandoned following the dissolution of the USSR (Schierhorn et al., 2013), but authors agree that this led to major carbon sequestration in soils (Kurganova et al., 2015). A process-driven ecosystem model (Vuichard et al., 2008) estimated that the conversion of 20 million ha of cropland to grassland resulted in an accumulated carbon sink of 64 TgC between 1991 and 2000. Estimates vary, however, due to the use of different methods and data and allowing for the conversion to forests, with the range being from –64 to –694 TgC sequestered (Dolman et al., 2012). Schierhorn et al. (2013), using a different process-based model, estimated that between 1990 to 2009 the 31 million ha of abandoned cropland in Western Russia, Ukraine, and Belarus combined, provided a net carbon sink of 470 TgC. In Central Asia, between 1982 and 2000, there was a decrease of soil organic carbon stocks of about 828 TgC, mainly due to the conversion of native rangelands into agricultural land, and to a lesser extent (5% of carbon losses) due to rangeland degradation (Sommer & de Pauw, 2011). Nitrogen deposition can increase terrestrial carbon sequestration and its effect is greatest in Central Europe, although across all subregions of Europe this effect is decreasing due to reduced deposition (Zaehle et al., 2011).

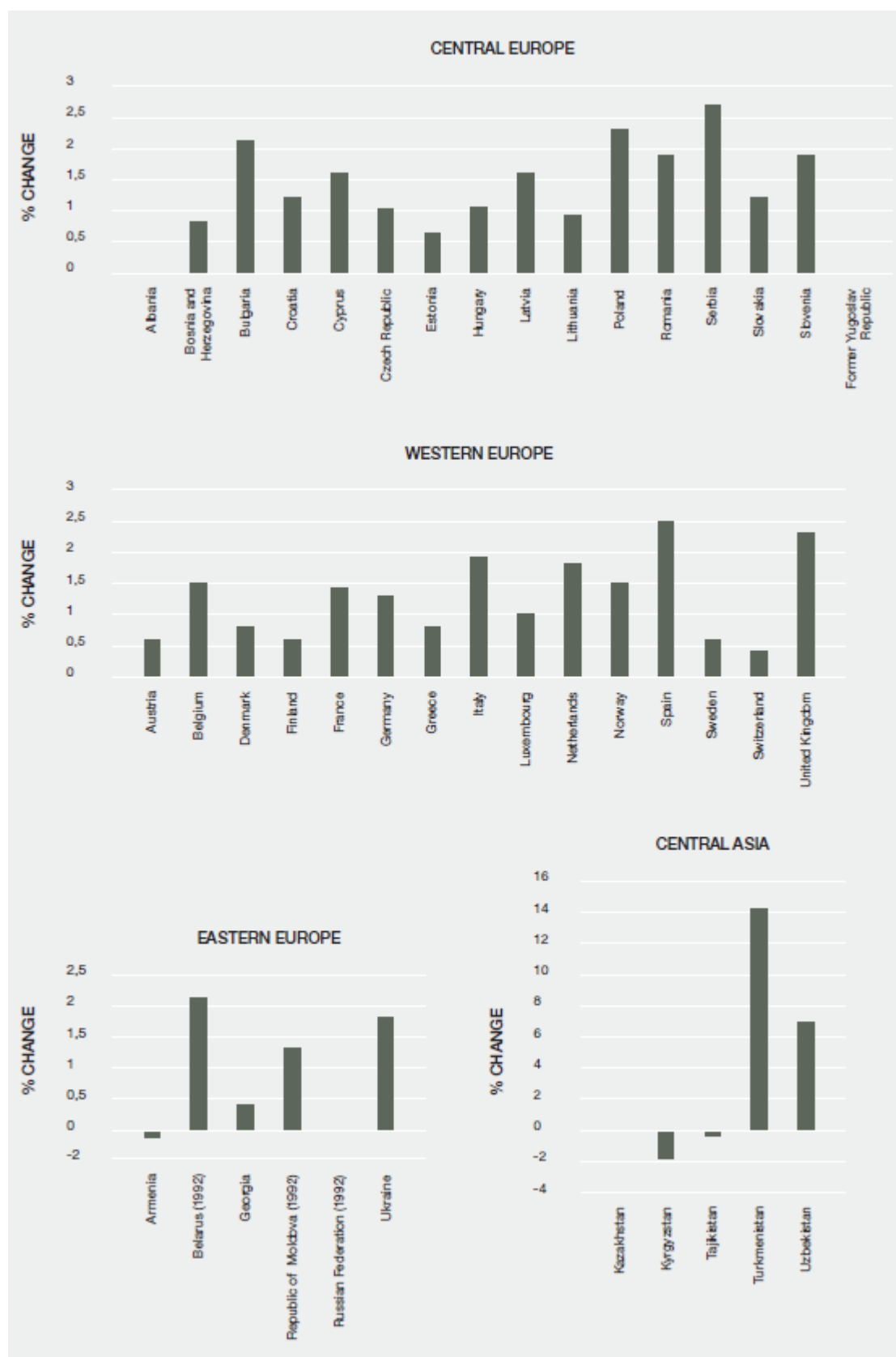


Figure 2.9: Annual rate of change (%) in carbon stock in living above-ground and below-ground forest biomass in Europe and Central Asia between 1990 and 2015. Own representation based on FAO (2015c).

Ecosystems, especially in urban areas, can be effective in microclimate regulation, through reducing local surface temperatures by shading, and air temperatures by evaporative cooling and albedo effects. Local climate regulation has been estimated for 301 large urban zones in the EU-27, using the amount of energy emitted by a surface (surface emissivity) and an approximation of the evaporation potential of the land surface (f-evapotranspiration) to calculate the effect of different land covers on urban air temperatures (Larondelle et al., 2014). Climate regulation was found to be low across most of Western, Central and Eastern Europe, but high in Sweden, Finland and some cities in Spain, France and Italy, with a more heterogeneous pattern elsewhere (see **Figure 2.10**). This primarily reflects the percentage of forest and tree cover in the core urban area and its hinterland.

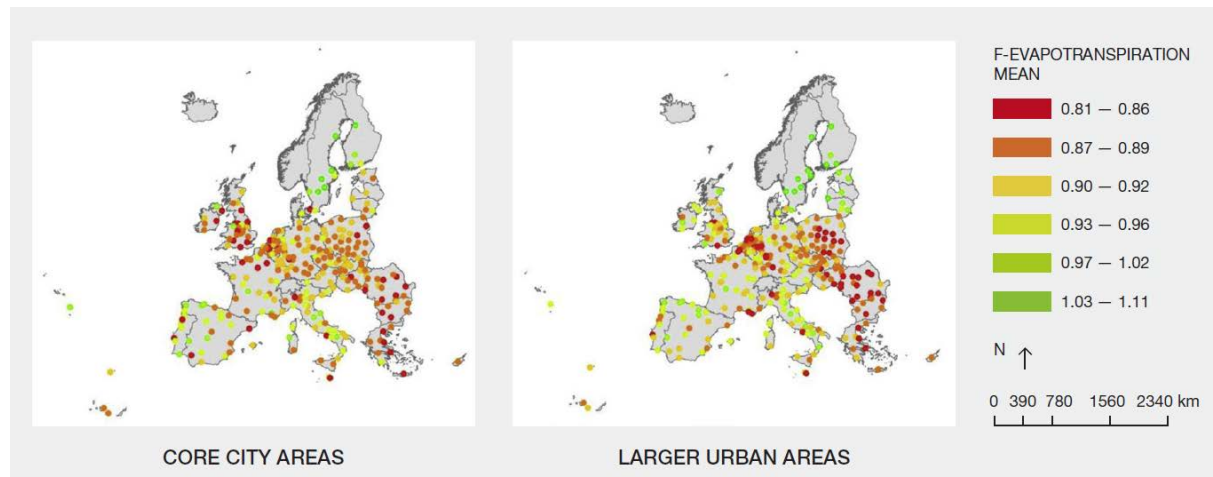


Figure 2.10: Urban heat regulation in cities in the EU-27, based on an approximation of the evaporation potential of the land surface (f-evapotranspiration). Low values indicate greater cooling (Larondelle et al., 2014). Core city areas on the left; larger urban areas on the right.

A global meta-analysis of the cooling potential of urban parks found an average reduction of ambient daytime temperature by 0.94°C and of nighttime temperature by 1.15°C (Bowler et al., 2010), although a few studies found small increases in temperature. The magnitude of the effects varies according to climatic region, size of park or forest (Bowler et al., 2010) and the species involved (e.g. Leuzinger et al., 2010)). For example, a comparison of temperatures in a street and the National Garden in Athens, Greece, found the greatest differences at night of up to 6.3°C cooling by the park (Zoulia & Santamouris, 2008), while in Manchester, UK, tree shading was found to reduce air temperatures by 1–2°C (Armson et al., 2012) and in an intra-urban park in Moscow, winter temperatures can be 0.74°C higher and summer temperatures 1.64°C lower than in the city centre (Shahgedanova et al., 1997).

Climate regulation by ecosystems contributes to other contributions from nature to people (e.g. habitat maintenance (Section 2.2.1.1), erosion control (Section 2.2.1.8), water quality (Section 2.3.1.6)), while carbon sequestration in soils can increase food security (Section 2.3.1.1). Furthermore, the reduction of urban temperatures in hot weather (Section 2.3.2) can lower rates of heat-related mortality and morbidity, especially in elderly and chronically ill individuals and socially vulnerable people and those with respiratory diseases (Hajat et al., 2010). A study of 12 Western and Central European cities suggested that this is particularly important in the Mediterranean region (Michelozzi et al., 2009).

2.2.1.5 Regulation of ocean acidification

Ocean acidification has been shown to affect marine organisms, having especially negative effects in calcifying organisms such as bivalves, brittle stars, sea urchins, coralline algae and corals (Cornwall et al., 2017; Cornwall et al., 2015; Kroeker et al., 2013) and on the contributions they provide to people (Lemasson et al., 2017). Some of these organisms live in or nearby coastal vegetated ecosystems, which have been shown to regulate atmospheric CO₂ concentrations and seawater pH (Cornwall et al., 2013; Hendriks et al., 2014) with effects on calcification processes of marine organisms important to humans (e.g. corals, bivalves or sea urchins) (IPBES, 2017b). Marine macrophytes, such as large brown macroalgae and seagrasses, are net CO₂ consumers, and their metabolism creates pH fluctuations in seagrass meadows and kelp forests where they are dominant species and very abundant. This regulation of pH can entail increases of 1 pH unit during the day (Lise Middelboe & Juel Hansen, 2007). This up-regulation can depend on many factors, such as plant biomass and structure, hydrodynamics, irradiance and day-length (Krause-Jensen et al., 2016). Vegetated habitats may, therefore, contribute to regulating ocean acidification and creating refugia for calcifying organisms (Hurd, 2015; Krause-Jensen et al., 2016). There is increasing evidence that pH increase can lead to an overall buffering of ocean acidification (Buapet et al., 2013; Hendriks et al., 2014; Krause-Jensen et al., 2015; Krause-Jensen et al., 2016). Nevertheless, pH in these habitats typically fluctuates, with higher pH during daytime due to CO₂ uptake by photosynthesis and lower pH at night due to respiration and release of CO₂. In fact, some studies postulate that macrophytes may amplify the negative effects of ocean acidification, at least for some organisms (Pettit et al., 2015; Roleda et al., 2015). The potential role of regulating ocean acidification of marine vegetated habitats may depend on the balance between positive effects in the daytime and negative effects during the night (Dorte Krause-Jensen et al., 2016). For example, long days in the Arctic vegetated habitats have been shown to promote the provision of refugia for calcifying organisms during summer (Krause-Jensen et al., 2015; Krause-Jensen et al., 2016), when organisms reproduce and are most vulnerable to ocean acidification (Kroeker et al., 2013; Lemasson et al., 2017). However, the long polar nights should result in a down-regulation of pH, potentially amplifying negative effects of ocean acidification during winter. However, calcifying organisms are likely less susceptible to low pH in the later conditions (Kroeker et al., 2013).

Despite the importance of marine vegetated habitats, declines of seagrass beds and kelp forests have been reported in many parts of Europe and Central Asia (Araújo et al., 2016; Boudouresque et al., 2009) (see Sections 2.2.1.1. and 3.3.2.3) For example, decline of the seagrass *Posidonia oceanica* has been reported across the entire Mediterranean Sea, and during the last 50 years between 11 and 52% of the documented surface area originally occupied by the species has been lost, with many existing meadows deteriorating (Telesca et al., 2015). It is predicted that this trend will continue and the functional extinction of *P. oceanica* meadows is foreseen by the middle of this century (Jorda et al., 2012), even if seagrasses are likely to benefit from increased CO₂ worldwide (Zimmerman et al., 2017). Therefore, organisms associated with seagrass communities that are deteriorating may be exposed in the future to lower pH regimes due to the loss of pH-buffering capacity (Hendriks et al., 2014). By contrast, these marine vegetated habitats may increase in the Arctic Ocean, led by warming of seawater (Krause-Jensen & Duarte, 2014). The predicted poleward expansion of macrophytes with seawater warming and reduced sea-ice cover (Jueterbock et al., 2013) may increase the potential for pH up-regulation during summer in Arctic marine systems (Krause-Jensen et al., 2016). Similarly, increased pelagic primary production, as forecast for parts of the Arctic Ocean, may also create local niches of high pH (Arrigo et al., 2008; Popova et al., 2012).

2.2.1.6 Regulation of freshwater quantity and flow

This contribution from nature to people involves the contribution of ecosystems to the regulation of the quantity and flow of surface and groundwater used for drinking, irrigation, and industrial purposes. Besides contributing to direct use, ecosystems can also regulate water flow to water-dependent natural habitats that in turn affect people downstream, including via floods and droughts. See electronic Appendix 2.2 with quotes from indigenous and local knowledge holders describing this contribution, in relation to seasonal water flows.

This section distinguishes between freshwater provision and water flow regulation. Freshwater supply describes freshwater available for human use. Water flow regulation, on the other hand, is described in terms of supply through the indicators of water retention, stream flow and base flow.

The general trend in freshwater supply in Europe and Central Asia, taking into account renewable internal freshwater resources per capita provided by the Food and Agriculture Organization of the United Nations (FAO, 2016), shows an overall decrease since 1992 (**Figure 2.11**). Freshwater demand, taking into account water use and water abstraction, shows a mixed but overall decrease for all subregions of Europe and Central Asia (EEA, 2015d; FAO, 2013) since the 1990s. Between 2000 and 2011, water abstraction has decreased for countries in the European Union (European Commission, 2015b).

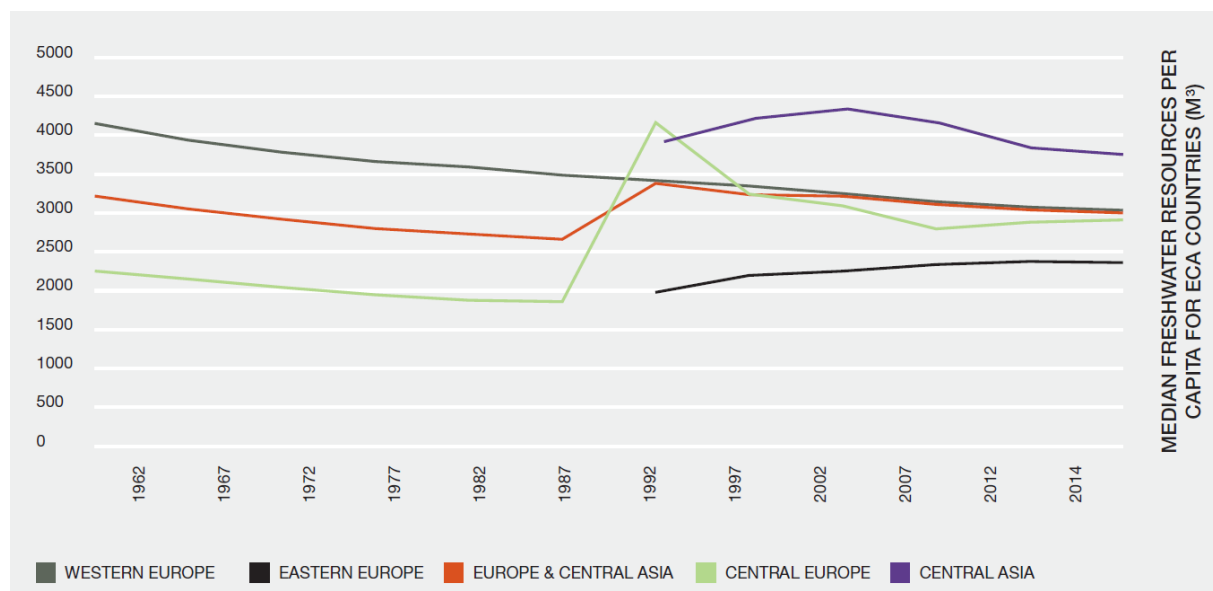


Figure 2.11: Trend of renewable internal freshwater resources per capita (median, in cubic meters) for Europe and Central Asia and the four subregions. Note that the trend for Europe and Central Asia until 1992 (dashed lines) is based on Western and Central Europe only. Own representation based on: (FAO, 2016).

Generally mixed but mostly decreasing trends in water flow regulation were found for parts of Western, Central and Eastern Europe (Stahl et al., 2010; UNEP/UNECE, 2016). Between 2000 and 2011, water flow regulation decreased for most ecosystems in the European Union (European Commission, 2015b). Regions with increased or stable water flow regulation are characterized by large areas of natural vegetation or extensive agriculture (Sturck et al., 2014).

Water supply in Western Europe, measured in freshwater availability, has been decreasing since the 1980s (FAO, 2016) (**Figure 2.11**). Decreased freshwater availability was also reported for Spanish riparian areas and rivers (Vidal-Abarca Gutiérrez & Suárez Alonso, 2013). Mixed trends for water

availability were found for Germany and Austria (Karabulut et al., 2016). Water demand in Western Europe, taking into account water use and surface water abstraction, has decreased since the early 1990s, although current trends are mixed (EEA, 2015d; Eurostat, 2016b). Water use has remained stable in the southern part but has decreased in the western part of Western Europe (EEA, 2015d). Groundwater extraction in Mediterranean river basins in France, Greece and Spain was reported to have increased (Skoulikidis et al., 2017), while overall groundwater extraction in Spain has decreased (Vidal-Abarca Gutiérrez & Suárez Alonso, 2013). Mixed trends for water use were found for the Danube basins in Germany and Austria (Karabulut et al., 2016) as well as water provision in the Llobregat basin in Spain. Mixed but predominantly increasing stream flow was found for Western Europe, although large differences exist between the north and the south (Stahl et al., 2010). Decreasing stream flow in the last decades was reported for the Mediterranean countries as well as Austria and Germany (Skoulikidis et al., 2017; Stahl et al., 2012). Decreased water flow regulation was reported for Spanish riparian areas (Vidal-Abarca Gutiérrez & Suárez Alonso, 2013). Mixed trends for stream flow were found in Switzerland (Lutz et al., 2016). Increased stream flow was found for the majority of the northern countries of Western Europe (Stahl et al., 2010, 2012), as well as in the Hula Wetland, Israel.

Water supply in Central Europe, measured in freshwater availability, has decreased since the 1990s, although this trend has been mixed in the past decade (FAO, 2016) (**Figure 2.11**). Mixed trends in water availability were discerned for Central European countries within the Danube basin (Karabulut et al., 2016). Water demand, taking into account water use and surface water abstraction in Central Europe, has declined sharply since the early 2000s, but this trend has been mixed in the past decade (EEA, 2015d; Eurostat, 2016b). Mixed trends for water abstraction have been reported for Central European Mediterranean river basins (Karabulut et al., 2016), whereas water abstraction in Cyprus has increased (Skoulikidis et al., 2017). Mixed but predominantly increasing stream flow was found for Central Europe (Stahl et al., 2010). Decreasing water flow during recent decades was reported for Cyprus, the Czech Republic and Slovakia, as well as the Sava River in Slovenia, Croatia, Bosnia and Herzegovina, Serbia, Montenegro and Albania (Lutz et al., 2016; Skoulikidis et al., 2017; Stahl et al., 2010). Stable water flow and ground water levels in the past were found in Slovenia and Poland.

Water supply in Eastern Europe, measured in freshwater availability, has increased since the 1990s and this trend has stabilized in the past decade (FAO, 2016) (**Figure 2.11**). Information on water demand in Eastern Europe is limited to a few countries, however, freshwater abstraction in the Republic of Belarus and the Republic of Moldova is reported to have decreased steadily over recent decades. A mixed trend for water demand was reported in the Eastern European countries of the Danube basin (Karabulut et al., 2016). Stream flow has decreased in most parts of Eastern Europe (Stahl et al., 2012). Water flow regulation in Russia was found to have increased between 1990 and 2015 (Miura et al., 2015).

Water supply in Central Asia, measured in freshwater availability, shows a mixed, but generally decreasing trend since the 1990s, and has continued to decrease over the past decade (FAO, 2016; SAEPP, UNEP, & UNDP, 2012) (**Figure 2.11**). Water availability per capita has decreased in Turkmenistan and Uzbekistan, while stable water availability was reported for the Aral Sea basin (Uzbekistan). Total water withdrawal in Central Asia has been stable in the past, while water withdrawal by agriculture, industry and cities has decreased (Alexander & West, 2011; FAO, 2013). There is some evidence of on-going stable water use in Uzbekistan (Aral Sea basin), as well as excess water use for irrigation on a local scale (Conrad et al., 2016). Mixed trends for water use were reported for Uzbekistan, due to strong regulation in response to droughts. Water extraction in the Kyrgyz Republic has decreased, although recent trends are mixed. Water use and availability have decreased

in Turkmenistan and Uzbekistan (FAO, 2013). Water flow regulation throughout Central Asia shows a mixed trend, following patterns in precipitation and drought occurrences (FAO, 2013; SAEPF et al., 2012).

Regulation of freshwater quantity and flow mostly contributes to quality of life by supporting water and food security (Section 2.3.1). Water security, which is furthermore underpinned by water quality regulation (Section 2.2.1.7) and other contributions from nature to people, is mostly sufficient and has increased in Europe and Central Asia since the late 1980s. More mixed trends and insufficient water security, notably in rural areas, are reported for Eastern Europe and Central Asia. Europe and Central Asia as a whole is food secure but food security is affected by, among others, decreasing water availability and excessive water withdrawal.

2.2.1.7 Regulation of freshwater and coastal water quality

This contribution from nature to people refers to nature's ability to remove or break down excess nutrients and other pollutants. The combination of physical, chemical and ecological processes in rivers, wetlands and marine ecosystems acts as a natural filter removing substances such as sediments and nutrients linked to nitrogen and phosphorus. Water quality regulation, therefore, depends on both the emission of pollutants into the water, and on the capacity of the natural systems to process or transform these substances and physically block them by sediments. For example, natural, restored and constructed wetlands in the European Union are estimated to remove 75% of the nitrate from agricultural runoff via denitrification (Blackwell & Pilgrim, 2011). Nature-based solutions associated with artificial wetlands and restoration of riparian zones have been demonstrated as cost effective measures for water quality improvement in Estonia, Norway, Sweden, Italy, Belgium and the UK (e.g. Kumaret al. (2017); MWO (2012); Zedler & Kercher (2005)). The capacity of ecosystems to deliver this contribution to people shows sharp local variations along the rivers inside watersheds. If upland riverbeds are well conserved and pollution is limited, water quality can be well regulated. Downstream, rivers are often impacted by land use intensification, riparian wetlands reduction, overexploitation of water resources and alteration of the river bed morphology. In the latter case, the capacity of rivers to regulate water quality is diminished.

The capacity to provide this contribution in Europe and Central Asia has reduced over recent decades due to the conversion and habitat loss of rivers, wetlands and coastal systems (see Section 3.2.2.2), leading to a 60% decrease in the areal extent of floodplains and wetlands and loss of watersheds' ecological integrity (Geijzendorffer et al., 2017). In 2017 it was estimated that 38% of rivers' surface in the European Union have good or high ecological status, 42% moderate state and 20% poor or bad status (Grizzetti et al., 2017). In 2009, 43% of water bodies still showed a good or high ecological status (EEA¹⁷), indicating a reduction of rivers with good status over the past eight years.

Despite the loss of ecological integrity and areal extent of floodplains and wetlands, the water quality of rivers in the European Union has been improving since the 1990s as a result of the reduction of pollutants (due to the Nitrates Directive (91/676/EEC) and European Union Water Framework Directive (2000/60/EEC)) or as a result of transnational efforts such as the Convention on the Protection of the Rhine. The improvement in water quality is, therefore, the consequence of reductions in pollution, rather than an enhancement of the ecosystems' capacity to provide this contribution from nature to people. The quality of drinking water and bathing water, and the effectiveness of wastewater treatment, continue to improve across the European Union (EEA, 2016e).

¹⁷ <https://www.eea.europa.eu/soer-2015/europe/freshwater>

3350 For example, the percentage of bathing water sites meeting the minimum water quality standards has
3351 increased to 96.1 % in 2015.

3352 In Western Europe, the capacity to regulate water quality has been diminished since 1990. For
3353 example, in Spain and Germany, it is considered the most degraded regulating contribution from
3354 nature to people (Spanish National Ecosystem Assessment, 2013). In the Mediterranean basin, the
3355 regulation of water quality by wetlands has been jeopardized by the decreasing ecological integrity
3356 and scarce water availability (Geijzendorffer et al., 2017; MWO, 2012). However, in other areas, water
3357 quality regulation by ecosystems has remained stable (e.g. England) (UK NEA, 2011) or has increased
3358 (e.g. Netherlands) (de Knecht, 2014). Despite this general negative trend, water quality in Western
3359 Europe has improved due to pollution reduction. After the adoption of the European Union Nitrates
3360 Directive and Water Framework Directive, water pollution showed a downward-trend. Still, many
3361 water bodies remain affected by dissolved inorganic nutrients and pesticides (SOER, 2015).

3362 In Central Europe, the overall decreasing trend, due to increased pollution and conversion of
3363 floodplains and wetlands, is illustrated in Turkey, Austria, Hungary, Romania and the Danube
3364 floodplain (e.g. Hainz-Renetzeder et al., 2015; Karadeniz et al., 2009; Pehlivanov et al., 2014)). In
3365 addition, the demand for water purification is increasing due to agriculture and urban expansion. In
3366 Eastern Europe, water quality currently displays a downward trend due to nitrogen surpluses from
3367 intensive agriculture or the conversion of natural ecosystems (e.g. Bouraoui & Grizzetti (2014)). In
3368 Russia, the capacity to regulate water quality by forests and tundra of Siberia and eastern Russia has
3369 remained stable in the past (Stolbovoi, 2002). However, in the southern regions of Russia, the
3370 Southern Urals and Western Siberia, this capacity was found to be lower (Stolbovoi, 2002). For Central
3371 Asia, published data is not available.

3372 Regarding the regulation of water quality in coastal and marine waters, the concentrations of
3373 dissolved inorganic nitrogen, oxidized nitrogen and orthophosphate have remained stable between
3374 1985 and 2012 in Seas of Europe (**Figure 2.12**) (EEA, 2015c). Monitoring stations in the southern area
3375 of the North Sea (historically affected by eutrophication) show a decreasing trend in nitrogen and
3376 phosphorus concentrations (**Figure 2.12**). The Baltic Sea, which is also affected by eutrophication,
3377 shows a decreasing trend in nitrogen concentration, but an increase in phosphate concentrations
3378 (**Figure 2.12**) (EEA, 2015c). The adoption of national marine strategies fostered by the Marine Strategy
3379 Framework Directive (2008/56/EC) has supported the improvement of water quality in coastal and
3380 marine waters of the European Union.

3381 The contributions of water quality regulation to quality of life are manifold, with particular interest for
3382 water security (Section 2.3.1.3), health (Section 2.3.2), and the enjoyment of recreational experiences
3383 in nature (Section 2.2.3.2). The restoration and construction of wetlands, together with the Nitrates,
3384 Water Framework the Marine Strategy Framework Directives of the European Union, are driving the
3385 decrease in water pollution. However, the loss of areal extent of wetlands and floodplains can
3386 jeopardize the future delivery of this contribution from nature to people.

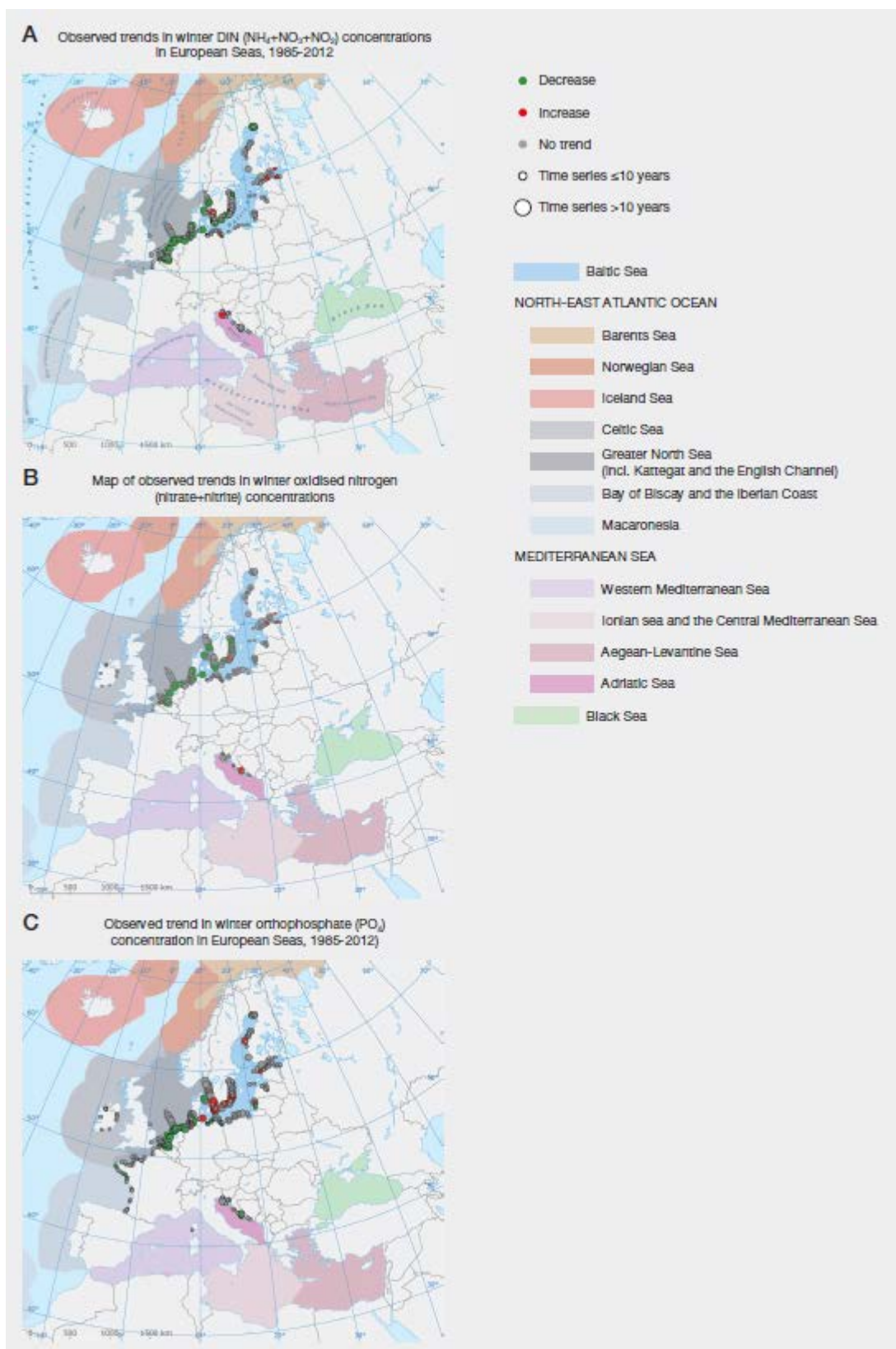


Figure 2.12: Stations of European Seas (Iceland Sea, Norwegian Sea, Celtic Sea, North Sea, Baltic Sea, Bay of Biscay and the Iberian Coast, Mediterranean Sea, Adriatic Sea and Black Sea) with available data for the period reported (1985-2012) showing a statistically significant decrease (green), increase (red) or no trend (grey) of (A) winter dissolved inorganic nitrogen, (B) oxidized nitrogen and (C) orthophosphate concentrations (EEA, 2015c).

3393

3394 **2.2.1.8 Formation and protection of soils**

3395 This contribution from nature to people relates to: (i) the central role of soils, which have high levels
 3396 of biodiversity and which are crucial to several other contributions such as food and feed provision,
 3397 freshwater quantity and quality regulation, climate regulation, hazards regulation; and (ii) the control
 3398 of erosion. In addition, threats to soil such as erosion, loss of organic matter and biodiversity
 3399 contamination, salinization, compaction, acidification and sealing) can severely decrease the ability of
 3400 soils to deliver this contribution (FAO, 2015b).

3401

3402 **2.2.1.8.1 Soil functioning: soil quality**

3403 Soil's essential functions are to capture, store and release carbon, nutrients and water; detoxify
 3404 contaminants and purify water; degrade and recycle wastes; control pests; host a wide diversity of
 3405 organisms; and create habitat for roots, fungi and invertebrates. The capacity of soil to perform these
 3406 functions is called soil quality (Karlen et al., 1997). Soil's quality depends on its inherent physical,
 3407 biological and chemical properties. Soil biota play a major role in this regard (European Commission,
 3408 2016c).

3409 Several indicators are used for soil quality (Karlen et al., 1997; European Commission, 2014c), soil
 3410 fertility (e.g., Burkhard et al., 2014; Mueller et al., 2014; Tóth et al., 2013), and for soil's ability to
 3411 naturally attenuate contaminants (e.g., Makó et al., 2017; Stone et al., 2016; Van Wijnen et al., 2012).
 3412 Soil organic carbon content, a widely used and frequently available indicator of soil quality (Lorenz &
 3413 Lal, 2016) is used here.

3414 Most cultivated soils of Europe and Central Asia are intrinsically fertile except the drylands of Central
 3415 Asia and salinized soils of Central Asia and Mediterranean Europe (FAO, 2015b; UNEP/UNECE, 2016)
 3416 (**Figure 2.13**). The organic carbon content of soils is very variable across land uses and soil types in
 3417 Europe and Central Asia (**Figure 2.14**), generally low in cultivated soil, and high in forest and
 3418 permanent grassland. Trends also vary with land use. While most grassland soils and forest soils
 3419 accumulate carbon, cultivated soils tend to lose carbon due to previous conversion from grassland
 3420 or forest to intensive and continuous arable land and to drainage (Jones et al., 2012). This loss has
 3421 been widely documented in Western Europe (e.g. Capriel (2013); Goidts & Wesemael (2007);
 3422 Heikkinen et al. (2013)), in Central Europe where about 70% of Turkish agricultural soils are losing soil
 3423 organic matter (FAO, 2015b), in Eastern Europe (Sychev et al., 2016) where more than 56 million ha
 3424 of agricultural mineral soils are losing organic matter (FAO, 2015b), and in Central Asia (Causarano et
 3425 al., 2011; Sommer & de Pauw, 2011) where the cultivation of virgin lands in Kazakhstan between 1982
 3426 and 2000 resulted in the loss of approximately 570 million tonnes of carbon from soils (FAO, 2015b;
 3427 Sommer & de Pauw, 2011). When alternative cropping practices such as conservation agriculture,
 3428 organic agriculture or agroforestry are implemented, soil organic carbon loss is reversed, along with
 3429 soil quality (e.g. Torralba et al. (2016)).

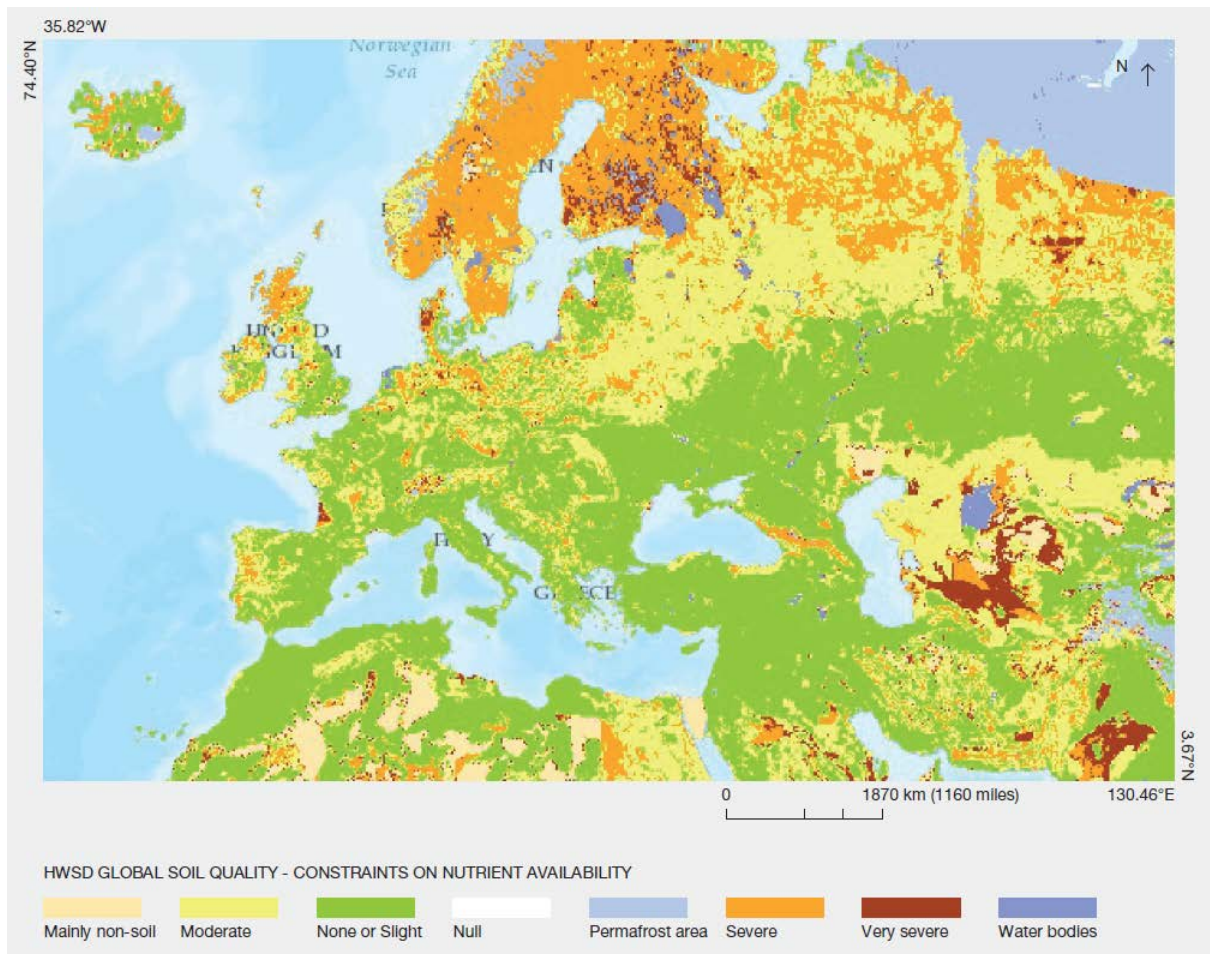


Figure 2.13: Soil quality indicated by constraints on nutrient availability. The more fertile the soils, the fewer constraints there are on nutrient availability to plants (none or slight, moderate, severe, very severe) (Fischer et al., 2012). Map extracted from Data Basin at <https://databasin.org/datasets/20dcb500682c4ec891e2fc881c2ed65c>

Land use changes occurring in Europe and Central Asia since 1990, such as afforestation and large-scale abandonment of cropland in the former USSR, resulted in increases in soil carbon content (Fuchs et al., 2016; Kurganova et al., 2015). A recent trend regarding the maintenance of fertile soils in Europe and Central Asia is the net loss of soil due to urbanization and sealing that occurs predominantly in Western Europe (Montanarella et al., 2015; EEA 2015) and preferentially at the expense of cropland (Figure 2.14) (EEA, 2015b).

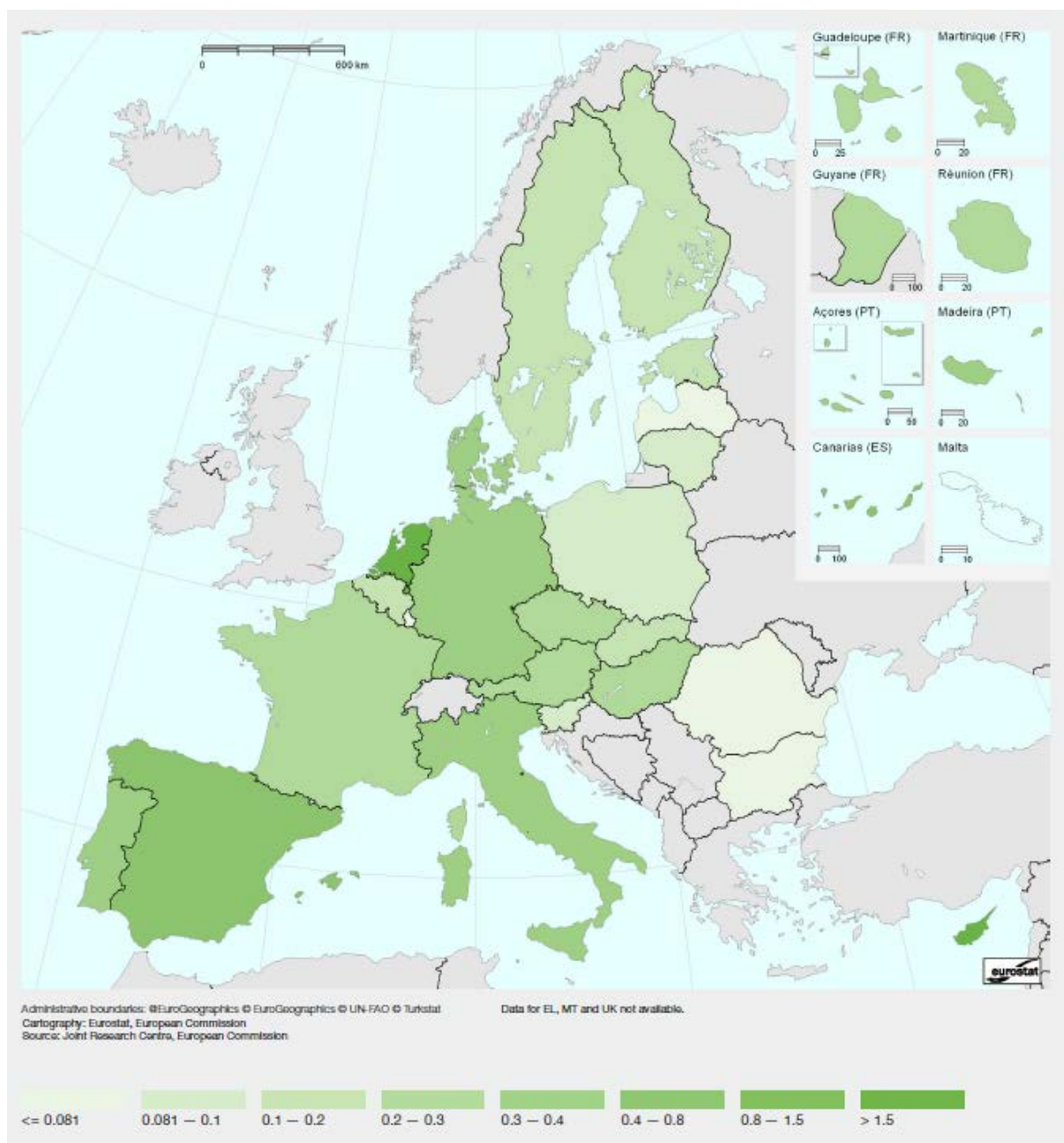


Figure 2.14: Change in agricultural land use expressed as a percentage of total agricultural area (%). 2000-2006, EU-27. On average 50% of land conversion in the European Union is at the expense of agricultural land (Eurostat, n.d.).

2.2.1.8.2 Erosion control

Soil erosion is the accelerated removal of soil from the land surface by water, wind or tillage. It threatens the sustainability of agriculture and forestry because of the loss of fertile topsoil, as well as causing damages off-site to settlements and infrastructure and affects the quality of surface waters. The severity of water erosion depends mainly on slope, soil erodibility, and soil cover by plants and litter (Lal, 2001b). Wind erosion depends on soil erodibility and soil cover (Lal, 2001a). Erosion, therefore, takes place mainly on vegetation-free surfaces and, therefore, primarily affects arable land.

3454 Soil erodibility depends particularly on soil texture and soil organic matter content (Le Bissonnais &
 3455 Arrouays, 1997).

3456 Erosion is the main soil degradation process in Europe and Central Asia (Stolte et al., 2015). Water
 3457 erosion dominates and affects a quarter of the EU-27 surface area (Jones et al., 2012; Panagos et al.,
 3458 2015), 26% of agricultural land in Russia (or 3.5% of total land (FAO, 2015b) and about 30% of
 3459 agricultural land in Moldova and Ukraine (FAO, 2015b). Wind erosion is less important in Western and
 3460 Central Europe, affecting 10% of surface area (Borrelli et al., 2014; A. Jones et al., 2012), but dominates
 3461 in Central Asia, where 23% of agricultural land is affected - nearly 80% of that in Uzbekistan (FAO,
 3462 2015b).

3463 Erosion control can be defined as the erosion avoided due to the vegetation cover or to a well-
 3464 aggregated soil (Guerra et al., 2016). The soil cover factor (C) of the “universal soil loss equation”
 3465 model for water erosion or its revised version, accounting for the effect of vegetation on water
 3466 erosion, is used as an indicator of the capacity to control erosion (European Commission, 2014c;
 3467 Panagos et al., et al., 2015). In the Mapping and Assessment of Ecosystem Services project), erosion
 3468 control by vegetation was estimated as: (i) the difference of eroded soil with and without vegetation;
 3469 and (ii) the capacity of ecosystems to avoid erosion (European Commission, 2015b).

3470 Vegetation cover is very heterogeneous in the EU-27 (**Figure 2.15**) (Panagos et al., 2015) and in Eastern
 3471 Europe and Central Asia (**Figure 2.16**) in relation to climate. With a lower C factor, the capacity of
 3472 ecosystems to avoid soil erosion is thus lower in Mediterranean areas of Europe and Central Asia
 3473 (**Figure 2.17**) (Kulikov et al., 2016). Vegetated soil cover has decreased in many areas of Europe and
 3474 Central Asia in relation to intensive cultivation, rangeland degradation and desertification (FAO,
 3475 2015b; Gupta et al., 2009; Le, Nkonya, & Mirzabaev, 2014). Management practices such as
 3476 conservation agriculture, cover crops and residue return, when implemented locally, increased the C
 3477 factor (Holland, 2004; Panagos et al., 2016; Panagos, et al., 2015).

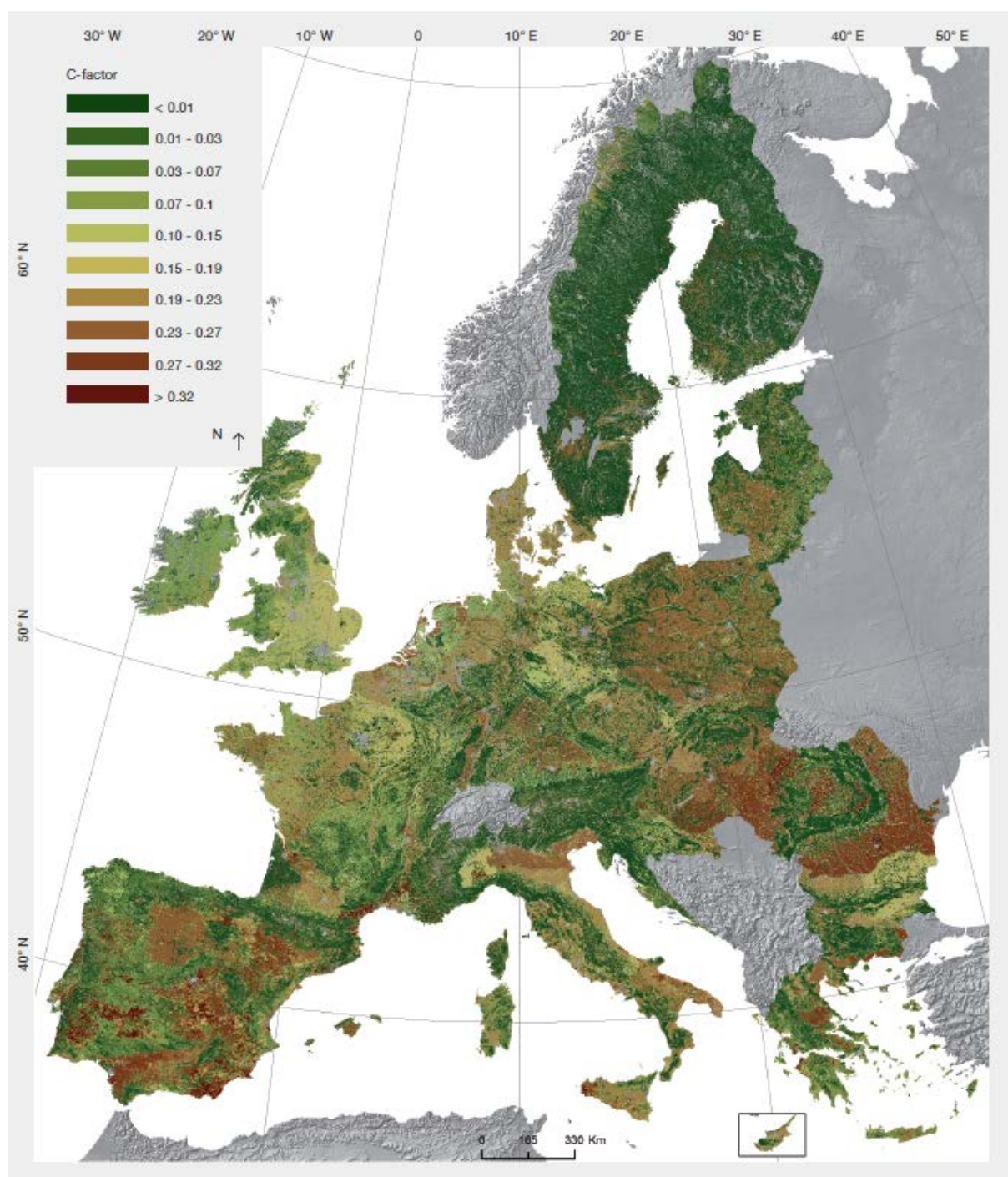


Figure 2.15: Soil erosion cover management factor (C factor) for the European Union (Panagos et al., 2015). This factor, which decreases with soil cover (1 to 0) is a multiplicative factor to estimate the amount of eroded soil per unit surface using the Revised Universal Soil Loss Equation (RUSLE) model.

Erosion control decreased on agricultural land over the last two decades in Europe and Central Asia and is still decreasing in many areas of Central Asia (FAO, 2015b; Gupta et al., 2009) and the East European plain in Eastern Europe (FAO, 2015b; Golosov et al., 2011; Sorokin et al., 2016). By contrast, erosion control has increased in the EU-27 between 2000 and 2010 by an average of 9.5%, and by 20% for arable lands (Panagos, et al., 2015) and in Mediterranean Europe between 2001 and 2013 (Guerra et al., 2016). Common Agricultural Policy intervention measures, promoting practices such as reduced tillage, residue return, cover crops, conservation agriculture, contour farming and grass strips can

explain this trend (Panagos, et al., 2015). In Central Asia, the surface area of cropland under conservation agriculture, albeit very small, has more than doubled between 2007 and 2011 (Buhlmann et al., 2010; Nurbekov et al., 2016).

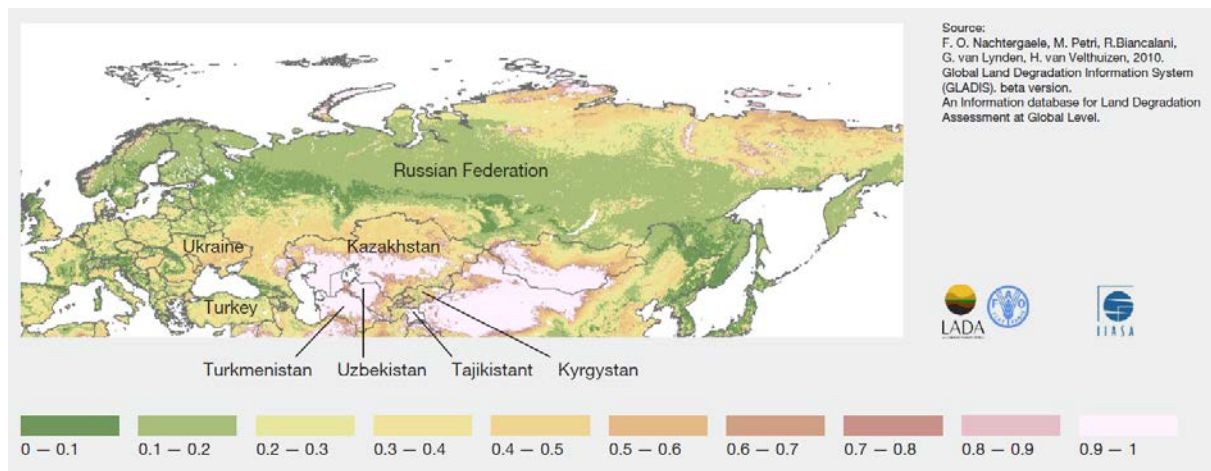


Figure 2.16: Soil erosion cover management factor (C factor) for Eastern Europe and Central Asia (Nachtergaele et al., 2010).

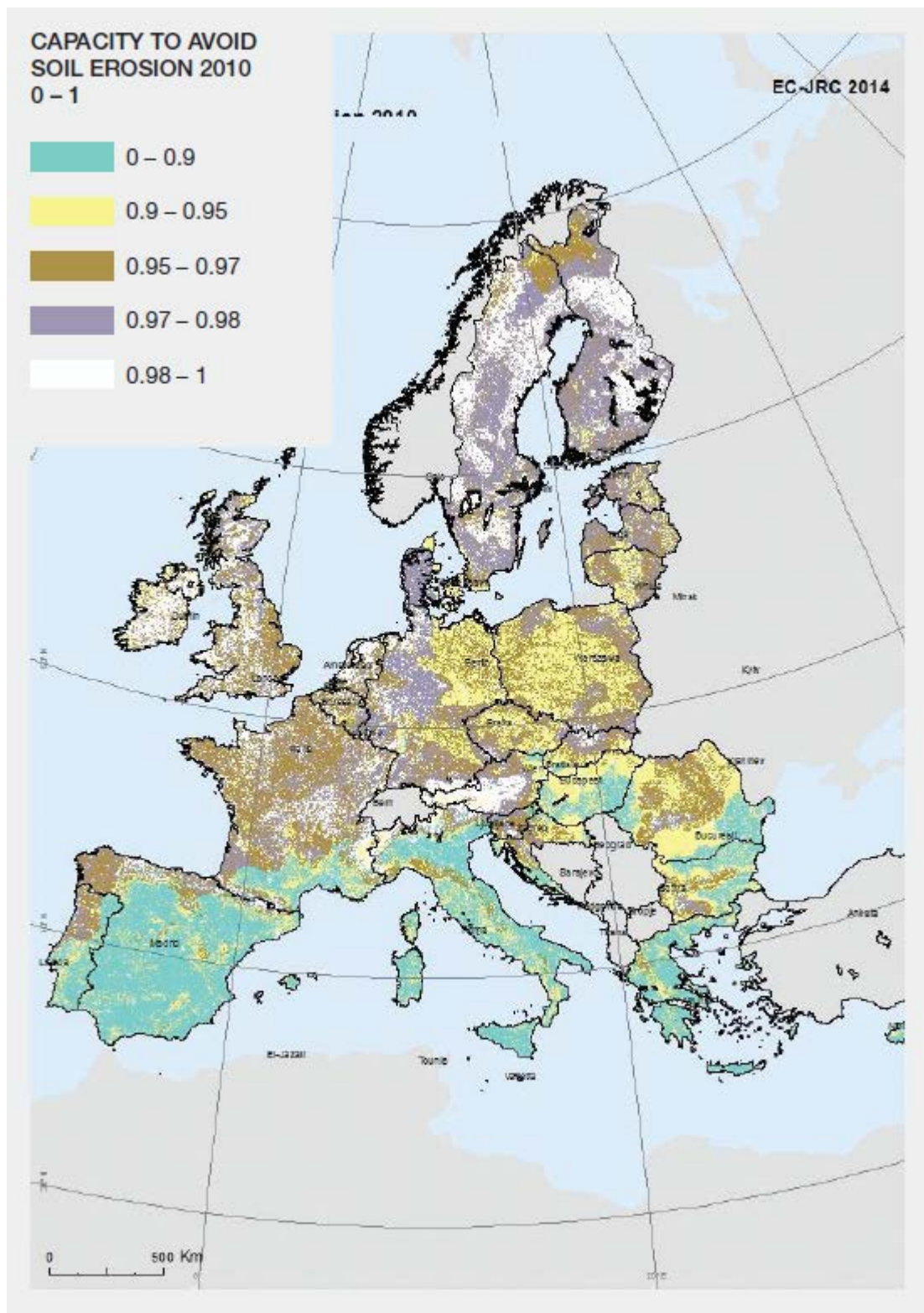


Figure 2.17: Capacity of ecosystems to avoid erosion (0= lowest capacity; 1=highest capacity) (European Commission, 2015b)

2.2.1.9 Regulation of natural hazards and extreme events

The Europe and Central Asia region is exposed to a range of natural hazards, including droughts, floods, landslides and avalanches, storms and wildfires. In the European Union, floods account for 40% of the damages by natural hazards and affect 50% of the population (European Commission, 2015c). With flooding being the most damaging natural hazard, this section focuses on trends of coastal and fluvial flood regulation, while we first briefly report on the general trends in the regulation of other natural hazards. Note that information on nature's capacity to regulate natural hazards is generally lacking for Europe and Central Asia, while information on the occurrence of natural hazards is more abundant.

The severity, frequency and persistence of meteorological and hydrological droughts have increased in Europe and Central Asia since the 1960s, although there are large differences across the region (EEA, 2016d; EM-DAT, 2017). Drought frequency in south-western and central Mediterranean Europe has increased, but has decreased in northern parts of Western Europe and parts of Eastern Europe (EEA, 2016d). The continued degradation and decline of wetland area (Section 2.2.1.7) has contributed to the reduced capacity to regulate droughts (Kumar et al., 2017).

The severity and frequency of landslides and avalanches have mixed trends for the region (EM-DAT, 2017), while an increase in fatal landslides is observed for Western, Central and Eastern Europe (Haque et al., 2016). The regulation of landslides is directly related to the amount of protected forest cover, especially in mountainous areas, and their protection status has changed little in recent decades (Miura et al., 2015).

The frequency and severity of wildfires has generally increased throughout Europe and Central Asia (EM-DAT, 2017) and this trend continues, notably in Eastern Europe (Gauthier et al., 2015) and causing changes in Mediterranean forests (Pausas et al., 2008). The regulation of wildfires depends strongly on the plant composition of forests, protective forest management, and preservation of forest health, the latter being negatively affected by climate change.

In coastal areas, floods are caused by storm surges and sea level rise, whereas fluvial flooding predominantly occurs due to intensive and enduring rainfall within a catchment (Reed, 2002). Nature's capacity to attenuate flooding is reported in terms of the extent to which floods are regulated, whereas the occurrence and severity of floods, as well as the damage caused. The impact of natural hazards depends on the number of people affected, which is increasing as more people live in risk prone areas, such as river floodplains or coastal areas (Dawson et al., 2009).

Information on nature's capacity to regulate floods in Europe and Central Asia is limited and generally shows a mixed trend. Increasing trends are reported for some countries of the European Union and Russia since the 2000s (European Commission, 2015b), but decreasing trends are reported for densely populated areas with intense rainfall and where most floodplain landscapes and wetlands have been heavily transformed (Heintz et al., 2012; Solín et al., 2011). In addition, the frequency and intensity of floods increased significantly from the 1980s to 2000, after which the number of floods stabilized at a high occurrence and severity (EEA, 2016b; EM-DAT, 2017) (see **Figure 2.18**). Almost 1,500 river floods have been reported for the European Union since 1980, of which more than half have occurred since 2000 (EEA, 2016b), although this increasing trend has a large inter-annual variability (EEA, 2016b; EM-DAT, 2017). The increasing number of severe floods is related to higher frequency of heavy precipitation events and decreased capacity to regulate fluvial floods.

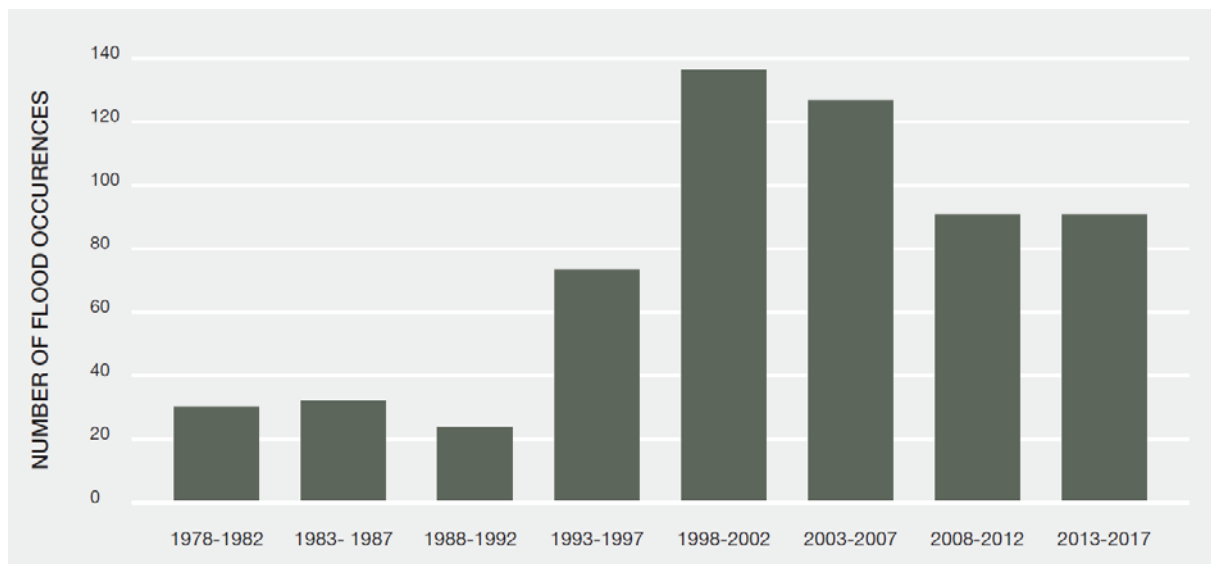


Figure 2.18: Trends of flood occurrence for Europe and Central Asia. Own representation based on EM-DAT (2017)

Although there are reported increasing trends for flood regulation for some Western European countries since the 2000s (European Commission, 2015b), general trends are mixed and not well established. However, the number of coastal and river floods in Western Europe has increased since the 1980s, with a strong peak in 2000, and has remained stable but fluctuating in the last decade (EEA, 2016b; EM-DAT, 2017). The strongest increase in number of floods was reported for the southern part of Western Europe, while this number has decreased for most of the northern countries in this subregion (EM-DAT, 2017). The number of severe and very severe floods follows the same trend, with the sharpest increases reported for Spain, Germany and France (EEA, 2016b). Western European countries, such as Germany and France, are ranked among the 20 countries world-wide most affected by weather-related catastrophes in the past 20 years, including floods or landslides after heavy rains (Kreft et al., 2016). The most affected countries in the period 1995-2014 in terms of deaths caused by these climate-change events were Italy, Spain and France (Kreft et al., 2016).

In Central Europe, increasing trends for flood regulation since the 2000s are reported (European Commission, 2015b), but general trends are mixed. Studies in Bulgaria, Hungary and Poland demonstrated decreased flood regulation over time, in addition to increases in precipitation (Acreman et al., 2007; Mrozik, 2016; Pehlivanov et al., 2014). The number of floods in Central Europe has increased significantly since the 1980s, and this trend has continued in the last decade (EEA, 2016b; EM-DAT, 2017). The number of severe river floods follows the same trend, with the sharpest increase reported for Bulgaria, Poland and Slovenia (EEA, 2016b). Periodic overload of drainage systems and local inundations were reported for Poland, as a result of transformation of areas of permeable surfaces (arable land) into impermeable areas (built-up areas) (Mrozik, 2016). Mixed trends of flood frequency were reported for Slovakia, while land cover change negatively affected the capacity to regulate floods (Solín et al., 2011). In addition, the Central European subregion, particularly Romania and Slovenia, has suffered higher damage due to climate-change events than Western Europe (Kreft et al., 2016).

No clear trends in flood regulation have been reported for Eastern Europe. However, the loss of forests and woodlands is assumed to negatively impact the capacity for natural flood mitigation (Bradshaw et al., 2007; Schmalz et al., 2016). In the Danube River Basin, the extent of floodplains has been reduced to 68% of their pre-regulation extent (Hein et al., 2016). Overall, the number and intensity of

floods in Eastern Europe has increased greatly since the 1980s, with a peak in 2000, and has remained mixed in the last decade (EM-DAT, 2017). Regular severe floods have been reported throughout the subregion including for Russia (EM-DAT, 2017). Russia has also been among the most affected countries in the period 1995-2014 in terms of deaths caused by extreme climatic events (Kreft et al., 2016).

No clear trends in flood regulation have been reported for Central Asia. The overall number and intensity of floods in the subregion has increased slightly since the 1990s, but has remained stable over the past decade (EM-DAT, 2017). Severe floods have been reported almost annually (EM-DAT, 2017).

Global warming and sea level rise are projected to increase the occurrence and frequency of flood events in large parts of continental Europe (EEA, 2016b; European Commission, 2015c). In addition, coastal flooding is expected to increase especially on the Mediterranean coast (Buyck et al., 2015; European Commission, 2015c). People and their quality of life are increasingly exposed as the capacity to regulate and mitigate floods is likely to continue to decrease with current urbanization trends (Zedler & Kercher, 2005).

2.2.1.10 Regulation of detrimental processes: removal of animal carcasses

Vertebrate scavengers in Europe and Central Asia are represented by old world vultures, which are obligate scavengers that depend totally on carrion, and facultative scavengers, i.e. mostly mammalian carnivores, suids, raptors and corvids, which exploit carrion opportunistically (Moleón et al., 2014). There are five vulture species in Europe and Central Asia: griffon (*Gyps fulvus*), Himalayan (*G. himalayensis*), cinereous (*Aegypius monachus*), Egyptian (*Neophron percnopterus*) and bearded vulture (*Gypaetus barbatus*). Vultures and particularly griffons (the most abundant species in the region) are especially efficient in locating and consuming carcasses (Morales-Reyes, et al., 2017; Sebastián-González et al., 2015) but, within Europe and Central Asia, their range is limited to the southern parts of Western, Central and Eastern Europe and Central Asia. Other raptors, particularly eagles (*Aquila* spp.) and kites (*Milvus* spp.), together with corvids (mainly *Corvus* spp.) are also key scavengers in Europe and Central Asia. Among mammalian facultative scavengers, canids (e.g., wolves *Canis lupus*, jackals *C. aureus*, and foxes *Vulpes* spp. and *Alopex lagopus*), bears (*Ursus arctos*), wolverines (*Gulo gulo*), and wild boars (*Sus scrofa*) are important for scavenging (Mateo-Tomás et al., 2015). Empirical evidence suggests that scavenging networks that include obligate scavengers are more efficient in the removal of carrion, including wild animal and livestock carcasses (Moleón et al., 2014; Morales-Reyes et al., 2017; Sebastián-González et al., 2015). In Europe and Central Asia, vertebrate scavengers remove an important fraction of the carrion biomass available (DeVault et al., 2003; DeVault et al., 2016; Mateo-Tomás et al., 2015), contribute to pest and disease regulation (Ogada et al., 2012) and nutrient cycling (Beasley et al., 2015; Wilson & Wolkovich, 2011). Indigenous and local knowledge holders also describe the role of vertebrate scavengers in providing this contribution from nature to people: “Even beasts are made by God and have a purpose, even the bad ones like wolves, they have their own role, they eat the corpses of dead animals, and they cleanse the landscape.” (Ivascu & Rakosy, 2016) (See electronic Appendix 2.2).

Most scientific evidence about the role of scavengers in carcass removal is from Western Europe, coinciding with the largest populations of vultures in this subregion (Margalida et al., 2010). For example, it has been estimated that the Spanish vulture population removes between 134 and 200 tonnes of bones and between 5,551 and 8,326 tonnes of carrion from the landscape every year (Margalida & Colomer, 2012). In addition, the artificial removal of extensive livestock carcasses in

Spain imposed by sanitary European Union regulations (Margalida et al., 2010) meant the emission of over 77,000 tonnes of CO₂ eq. to the atmosphere per year and the annual payment of about \$50 million to insurance companies by farmers and administrations (Morales-Reyes et al., 2015). In the Massif Central (France) alone, up to 33.1 tonnes of CO₂ per year could be saved if vultures were allowed to access livestock carcasses (Dupont et al., 2012). In Central Europe, particularly in Serbia, jackals annually remove more than 3,700 tonnes of animal remains (Ćirović et al., 2016).

The population of obligate and facultative scavengers determines the capacity for carcasses removal. Vultures have suffered sharp declines in Europe and Central Asia due to intended and unintended poisoning (e.g. Mateo-Tomás et al. (2012)), electric infrastructures such as wind farms and electric pylons (Carrete et al., 2009; Sánchez-Zapata et al., 2016) and, occasionally, veterinary drugs such as diclofenac (Green et al., 2016; Margalida et al., 2014a; Margalida et al., 2014b). In fact, avian scavengers are the most threatened functional group of birds in Europe and Central Asia (Sekercioglu et al., 2004). However, the trends of vulture populations vary across Europe and Central Asia (see **Table 2.3**, electronic Appendix 2.4). In Western Europe, where the major strongholds of vultures exist, particularly in Spain (home to >90% of European vultures (Margalida et al., 2010)), vultures have recovered over recent decades after strong declines since the 1950s (Donazar et al., 2016) due to reintroduction and conservation programs (e.g. Eliotout et al. (2007; Xirouchakis (2010)). By contrast, the situation of vultures in Central Europe is critical, although different conservation programs seek to recover their populations (e.g. Demerdzhiev et al. (2014); Grubač et al. (2014); Kirazli & Yamac (2013)). Available information for Eastern Europe and Central Asia is very scarce for obligate scavengers, while facultative scavengers overall exhibit an increasing trend in distribution range and population size across these subregions ((Chapron et al., 2014), **Table 2.3**, electronic Appendix 2.4).

There are several drivers that can threaten the supply of this contribution from nature to people including the conflicting policies that might change the capacity of obligate and facultative scavengers to remove animal carcasses. For example, sanitary policies might restrict the access of scavengers to the carcasses of domestic and wild ungulates (Margalida et al., 2010; Margalida & Moleón, 2016). The implementation of sanitary regulations after the outbreak of bovine spongiform encephalopathy in the European Union (Donazar et al., 2009) had a negative impact on vulture conservation (Margalida & Colomer, 2012) and the functional role of facultative scavengers such as kites and wolves (Blanco, 2014; Lagos & Bárcena, 2015). Nevertheless, recent changes in the European Union sanitary regulation have largely improved this situation (Zebensui Morales-Reyes et al., 2017). In addition, the intensification in livestock raising and the decline of traditional farming practices may threaten the removal of carcasses by scavengers (Olea & Mateo-Tomás, 2009). Finally, farmers' perceptions and their conflicting relations with facultative scavengers due to livestock predation can influence their tolerance towards these animals (Morales-Reyes et al., 2017).

Table 2.3: Conservation status (according to IUCN Red List categories) and population trend of main scavenger species (species selection based on (Mateo-Tomás et al., 2015)) per subregion of Europe and Central Asia. Trends are reported as: increasing (+); decreasing (–); stable (0); fluctuating (F); heterogeneous trend within the subregion (mixed; see electronic Appendix 2.4 for additional details of avian scavengers) or unknown (?). NA: data not available (i.e., there are no populations). Conservation status: EN: Endangered; VU: Vulnerable; NT: Near Threatened; LC: Least concerned. Own representation based on: (Chapron et al., 2014; Deinet et al., 2013; Wilson et al., 2009); IUCN Red List of Threatened Species. Version 2017-1. [www.iucnredlist.org](http://datazone.birdlife.org/info/euroredlist); BirdLife International (2015) <http://datazone.birdlife.org/info/euroredlist>

Common name	Scientific name	Scavenger group	Functional group	Conservation status	Current population trend	Western Europe	Central Europe	Eastern Europe	Central Asia
Bearded vulture	<i>Gypaetus barbatus</i>	Vulture	Obligate scavenger	NT	–	mixed	mixed	mixed	?
Griffon vulture	<i>Gyps fulvus</i>	Vulture	Obligate scavenger	LC	+	+	mixed	mixed	?
Himalayan vulture	<i>Gyps himalayensis</i>	Vulture	Obligate scavenger	NT	0	NA	NA	NA	?
Egyptian vulture	<i>Neophron percnopterus</i>	Vulture	Obligate scavenger	EN	–	mixed	mixed	mixed	?
Cinereous vulture	<i>Aegypius monachus</i>	Vulture	Obligate scavenger	NT	–	+	mixed	mixed	?
Golden eagle	<i>Aquila chrysaetos</i>	Apex predator	Facultative scavenger	LC	0	mixed	mixed	mixed	?
Spanish imperial eagle	<i>Aquila adalberti</i>	Apex predator	Facultative scavenger	VU	+	+	NA	NA	NA
Black kite	<i>Milvus migrans</i>	Generalists	Facultative scavenger	LC	?	mixed	mixed	mixed	?
Red kite	<i>Milvus milvus</i>	Generalists	Facultative scavenger	NT	–	mixed	mixed	mixed	NA
Common buzzard	<i>Buteo buteo</i>	Generalists	Facultative scavenger	LC	0	mixed	mixed	mixed	?
Western marsh harrier	<i>Circus aeruginosus</i>	Predator	Facultative scavenger	LC	+	mixed	mixed	mixed	?
Raven	<i>Corvus corax</i>	Corvids	Facultative scavenger	LC	+	mixed	mixed	mixed	?
Common magpie	<i>Pica pica</i>	Corvids	Facultative scavenger	LC	0	mixed	mixed	mixed	?
Carrion crow	<i>Corvus corone</i>	Corvids	Facultative scavenger	LC	+	mixed	mixed	mixed	?
Eurasian jay	<i>Garrulus glandarius</i>	Corvids	Facultative scavenger	LC	0	mixed	mixed	mixed	?
Yellow-legged gull	<i>Larus michahellis</i>	Seabirds	Facultative scavenger	LC	+	mixed	mixed	?	NA
Grey wolf	<i>Canis lupus</i>	Apex predator	Facultative scavenger	LC	0	+	+	–	?
Brown bear	<i>Ursus arctos</i>	Apex predator	Facultative scavenger	LC	0	+	+	–	?
Polar bear	<i>Ursus maritimus</i>	Apex predator	Facultative scavenger	VU	?	–	NA	–	NA
Wolverine	<i>Gulo gulo</i>	Generalists	Facultative scavenger	LC	–	+	NA	–	NA
Golden jackal	<i>Canis aureus</i>	Generalists	Facultative scavenger	LC	+	+	+	?	?
Red fox	<i>Vulpes vulpes</i>	Generalists	Facultative scavenger	LC	0	0	0	0	?

Arctic Fox	<i>Vulpes lagopus</i>	Generalists	Facultative scavenger	LC	0	0	NA	0	NA
Stone marten	<i>Martes foina</i>	Generalists	Facultative scavenger	LC	0	0	0	0	?
Pine marten	<i>Martes martes</i>	Generalists	Facultative scavenger	LC	0	+	+	+	?
Common genet	<i>Genetta genetta</i>	Generalists	Facultative scavenger	LC	0	0	NA	NA	NA
Eurasian badger	<i>Meles meles</i>	Generalists	Facultative scavenger	LC	0	0	0	0	?
Asian Badger	<i>Meles leucurus</i>	Generalists	Facultative scavenger	LC	?	NA	NA	?	?
Egyptian mongoose	<i>Herpestes ichneumon</i>	Generalists	Facultative scavenger	LC	0	0	NA	NA	NA
Wild boar	<i>Sus scrofa</i>	Omnivore	Facultative scavenger	LC	?	+	+	+	?

3663

3664 The removal of carcasses by scavengers contributes to different dimensions of people's quality of life.
 3665 The removal of scavengers may increase the incidence of infectious diseases (Ogada et al., 2012). In
 3666 addition, supplanting the ecosystem service provided by scavengers in agroecosystems with artificial
 3667 removal of livestock could raise greenhouse gas emissions, with important environmental and
 3668 economic costs (see above (Morales-Reyes et al., 2015; Morales-Reyes et al., 2017)). Vulture declines
 3669 also have a negative impact on the cultural identity of farmers and the value they derive from knowing
 3670 that these species exist (Morales-Reyes et al., 2017) (see Section 2.2.3.3).

3671

3672 2.2.2 Status and trends of nature's material contributions to people

3673 2.2.2.1 Food and feed

3674 2.2.2.1.1 Food and feed from terrestrial ecosystems

3675 Agroecosystems, including croplands, grasslands and agroforestry systems, cover an important area
 3676 of Europe and Central Asia, providing crops and animal-derived products that support the region's
 3677 food security (Section 2.3.1.1) and food culture (see **Box 2.1** and **Box 2.2**). FAOSTAT provides extensive
 3678 data on the quantity of this contribution delivered nature to people. However, other terrestrial
 3679 ecosystems, such as forests and scrublands, also provide food in the form of game, fruits and
 3680 mushrooms, for which little quantification is available, but see Section 2.2.3.2. Comprehensive data
 3681 on food quality has not been found, but the relationships between food production and the
 3682 characteristics of diet and health are explored here and in Sections 2.3.1.1 and 2.3.2.

3683 Overall the agricultural area per capita has been decreasing in Europe and Central Asia since the 1960s,
 3684 particularly in Western Europe, however, the cultivated area per worker in the agriculture sector has
 3685 almost tripled in Europe and Central Asia since the 1980s (**Table 2.4**), a process that goes hand in hand
 3686 with the mechanization and intensification of agriculture (**Table 2.4**, Section 4.5.2). Particularly, in the
 3687 Mediterranean basin, quantity and quality of food delivered by agroecosystems is severely influenced
 3688 by rural abandonment of mountainous and less productive areas and land-use intensification of fertile
 3689 areas (Caraveli, 2000) (Section 4.5.2).

Food production from agriculture in Europe and Central Asia increased by 56% between the 1960s and the 1990s. It then suffered a decline of 33% until 2014. The three socio-political events that have most influenced these trends are: the dissolution of the USSR in 1989, affecting mostly Central Asia and Eastern Europe (Kraemer et al., 2015); the Yugoslav Wars from 1991 to 1999 disturbing mostly Central Europe; and the Common Agricultural Policy of the European Union and its reforms (particularly since the MacSharry reform in 1992), influencing trends in Western and Central Europe.

Table 2.4: Historical trends of different indicators used to assess food provision as a contribution from nature to people. Red arrows indicate decreasing, yellow arrows indicate stable, green arrows indicate increasing and black arrows indicate mixed trends. Own elaboration based on different data sources: FAOSTAT (2017); OECD (2017); World Bank (2017).

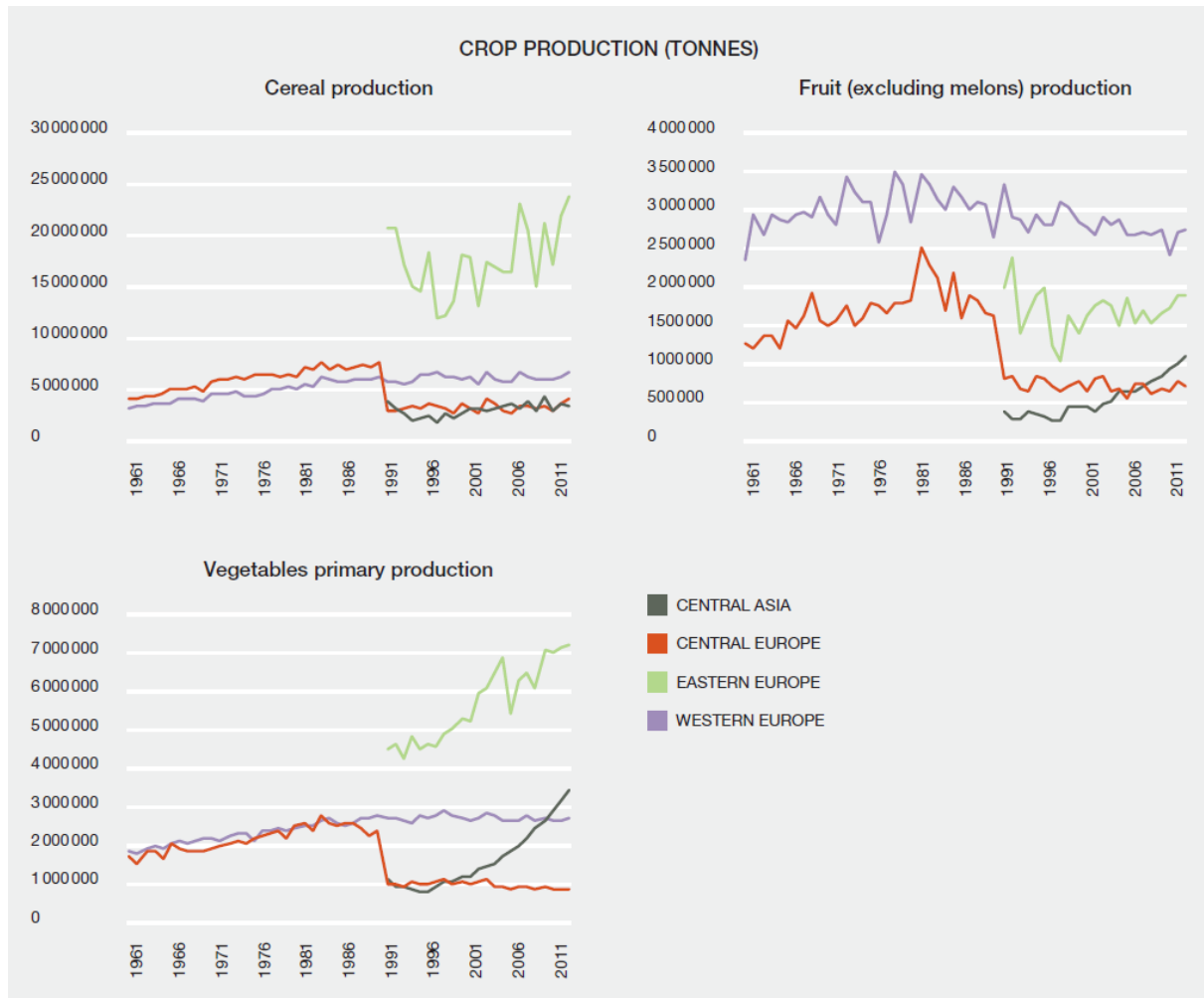
3701

BENEFIT	INDICATOR	Western Europe	Central Europe	Eastern Europe	Central Asia	ECA
CROPS	Agricultural area (hectares per capita)	↓	↓	↓	↓	↓
	Cultivated area per agricultural population (hectares per capita)	↑	↑	↑	↕	↑
	Agricultural tractors per 1000 hectares of agricultural area	↕	↕	↓	→	↕
	Permanent crops (% of agricultural area)	↕	↕	↓	→	↕
	Production of cereals per person (kg / person)	↕	↕	↕	↕	↕
	Production of fruit per person - excluding melons (kg / person)	↕	↕	↕	↕	↕
	Fertilizer consumption (kilograms per hectare of arable land)	↕	↕	↓	↕	↕
	Intensity of total pesticides use (tons / hectare of cultivated area)	↕	↕	↕	↕	↕
	Substance use for seed treatment - fungicides and insecticides (tons / hectare of cultivated superficie)	↑	↕	↕	↑	↕
	Total actual renewable water resources withdrawn by agriculture (%)	↕	↓	↕	↓	↕
	Conservation agriculture area (% of cultivated area)	↑			↑	
	Organic agricultural area (% of total agricultural area)	↑	↑	→	→	↑
	Agricultural raw materials exports (% of merchandise exports in dollars)	→	↕	↕	↕	↕
	Agricultural raw materials imports (% of merchandise imports in dollars)	↓	↕	↓	↓	↕
	Cereal production (% of world production)	↕	↕	↕	↕	↕
LIVESTOCK	Domestic mammals per rural inhabitant (except pack animals)	↑	↕	↕	↕	↕
	Poultry animals per rural inhabitant	↕	↕	↕	↕	↕
	Pack animals per square km of agricultural area	↕	↓	↕	↑	↓
	Combine harvesters - threshers per 1000 hectares of agricultural area	↕	↕	↓	→	↕
	Milking machines per head of cattle	↕	↕	↓	↕	↕
	Meadows and permanent pasture (% of agricultural area)	→	↑	↑	→	↑
	Production of meat per person (kg / person)	↕	↕	↕	↕	↕
	Meat production (% of world production)	↓	↕	↕	↕	↕

3702

3703 The assessment of different agricultural products shows different trends across subregions. Cereals
 3704 were mostly produced in Eastern Europe, where production has suffered fluctuations in recent
 3705 decades (see **Figure 2.19**). Among cereals, however, maize is experiencing substantial growth (see
 3706 **Figure 2.20**) because of its use for biofuel and feed production (see Sections 2.2.2.2 and 2.3.1.4). Fruit
 3707 has been produced mostly in Western Europe, but Central Asia and Eastern Europe have been
 3708 increasing their production in the past decade (see **Figure 2.19**). Countries in Eastern Europe are the
 3709 largest producers of vegetables, which has been experiencing growth (from ca. 4.5 million tonnes in
 3710 1991 to more than 7 million tonnes in 2012), as rapidly as in Central Asia (from ca. 1 million tonnes in
 3711 1991 to more 3.5 tonnes in 2012) (see **Figure 2.19**). Important crops in Europe are those required for

oil production (with increasing trends) and wine (with decreasing trend) (see **Figure 2.19**). Areas for organic agriculture in Western and Central Europe have been increasing since 2005 (in Western Europe from ca. 4% of the total agricultural area to more than 5%; in Central Europe from almost 1% to more than 4%) (see **Figure 2.21**) (FAOSTAT, 2017).



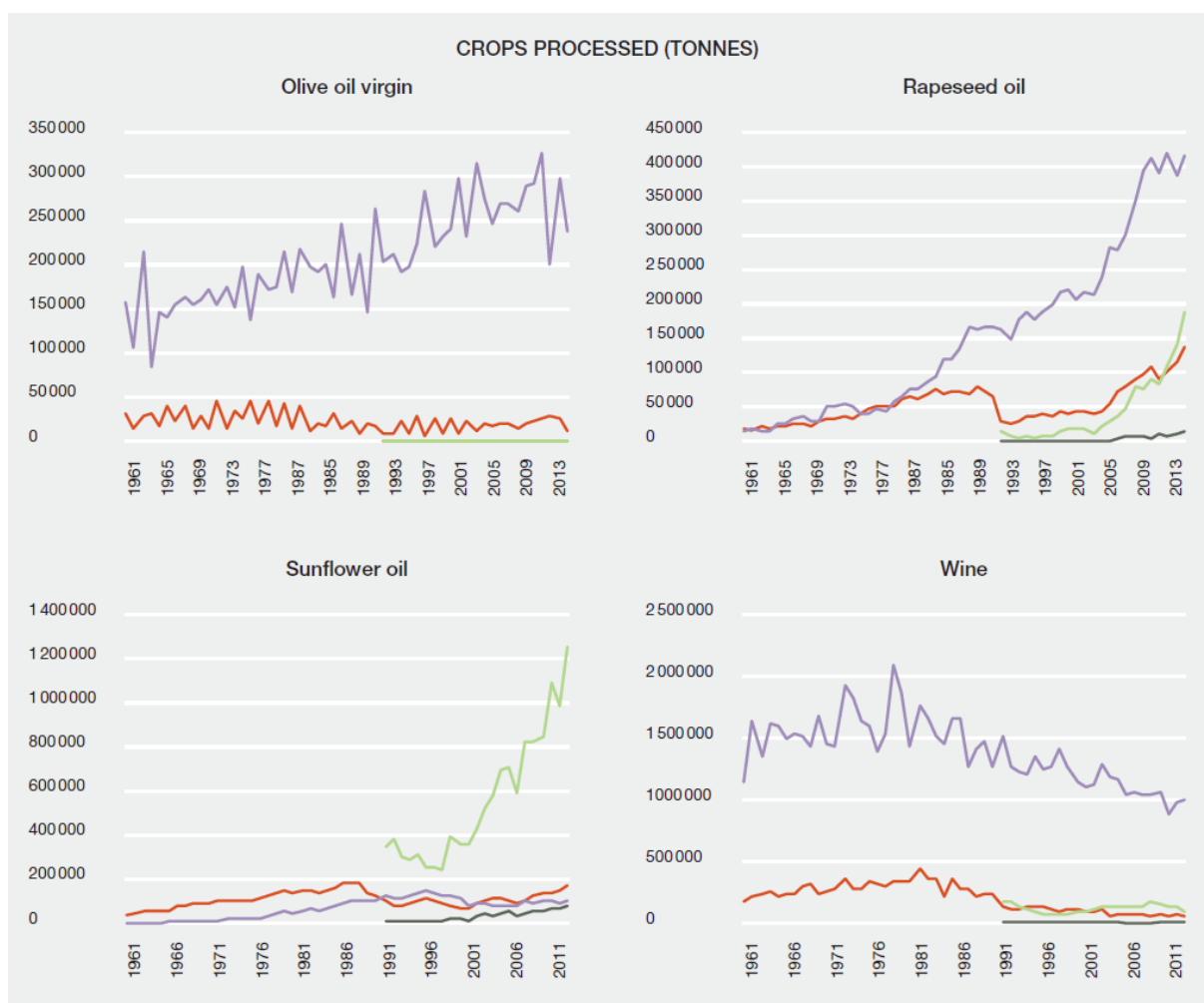


Figure 2.19: Historical trends for average country production (tonnes) in each subregion: crop primary production of cereals, fruit (excluding melons) and vegetable crops; and crops processed for olive oil virgin, rapeseed oil, sunflower oil and wine. Note that the y axes are on a different scale. Own elaboration based on data from the Food and Agriculture Organization of the United Nations (FAO, 2017).

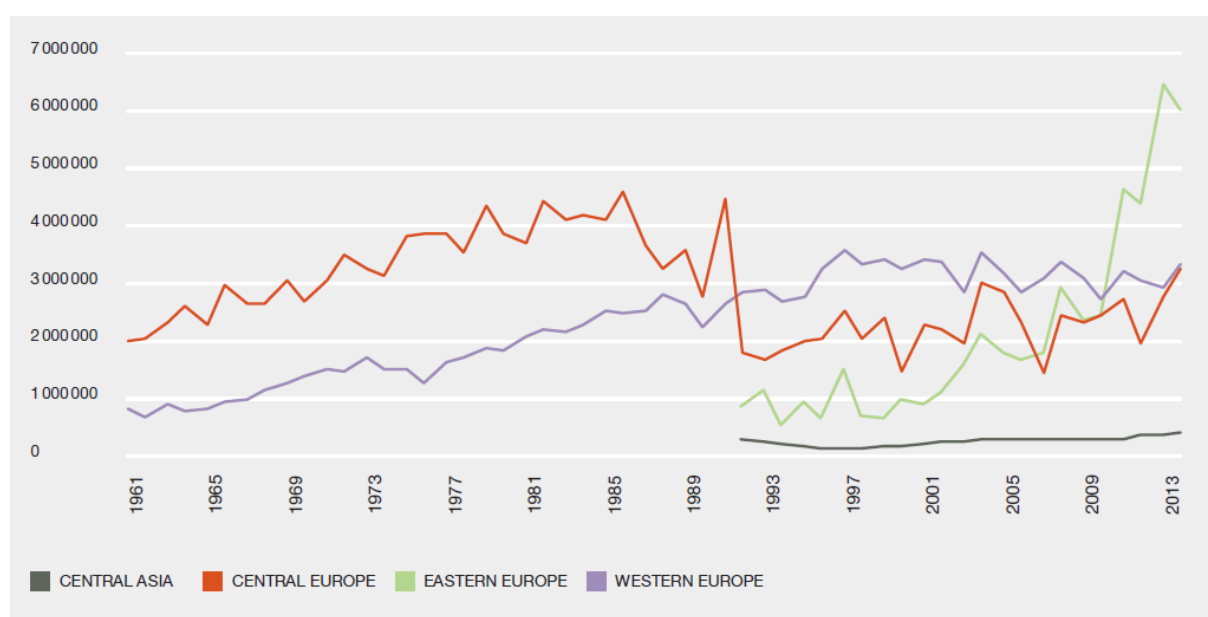


Figure 2.20: Historical trends for average country production (tonnes) of maize in each subregion. Own elaboration based on data from the Food and Agriculture Organization of the United Nations (FAO, 2017).

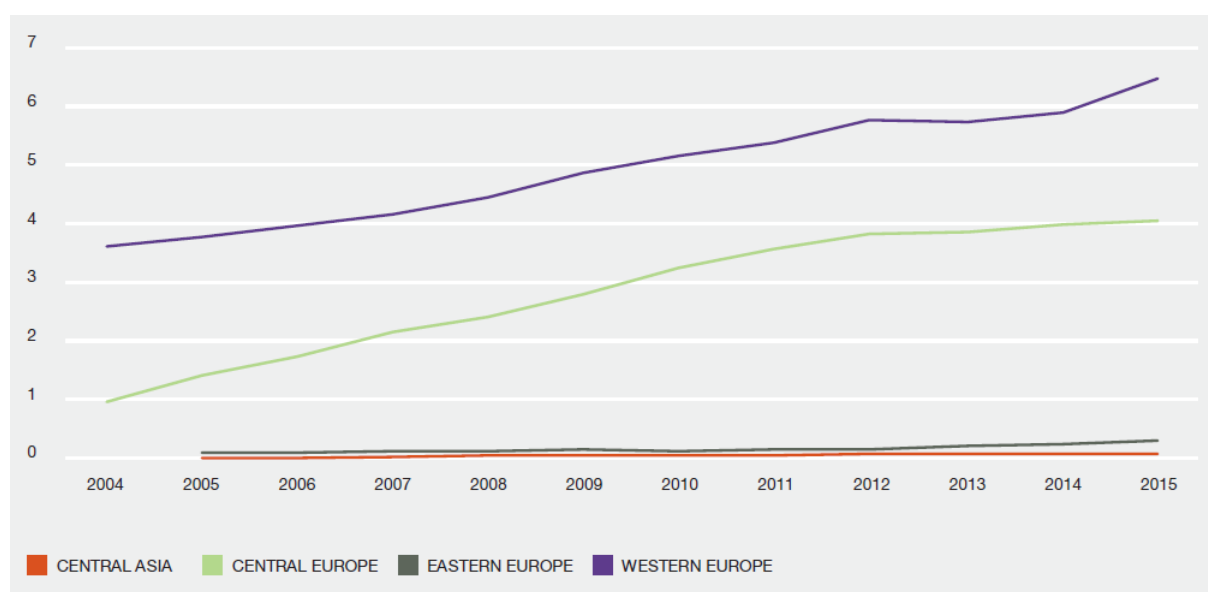


Figure 2.21: Historical trends of organic agriculture area (% of total agricultural area) in each subregion. Own elaboration based on data from the Food and Agriculture Organization of the United Nations (FAO, 2017).

The production of livestock primary production varies. Meat production increased between 1961 and 1990, when a sharp decline occurred in Eastern and Central Europe due to the dismantling of the Soviet Union (see **Figure 2.22**). However, since the early 2000s the trend changed in Eastern Europe and it is currently producing almost half of the meat in the region. Egg production follows a similar pattern, except in Eastern Europe with an increasing trend since 1996. Milk production has been decreasing since the 1990s (largely due to the introduction by the Common Agricultural Policy of the European Union of milk quotas), except in Central Asia. The countries with the largest production in

3741 the region in 2013 were Russia and Ukraine for eggs, Russia and Germany for meat, and Germany and
3742 Russia for milk. The production of livestock feed in EU-28 has experienced a sharp increase of more
3743 than 50% over the past three decades, consistent with the intra-regional trade balance of increasing
3744 import of ingredients of these feeding compounds such as soybeans, and with the above-mentioned
3745 intensification of livestock farming in the European Union.

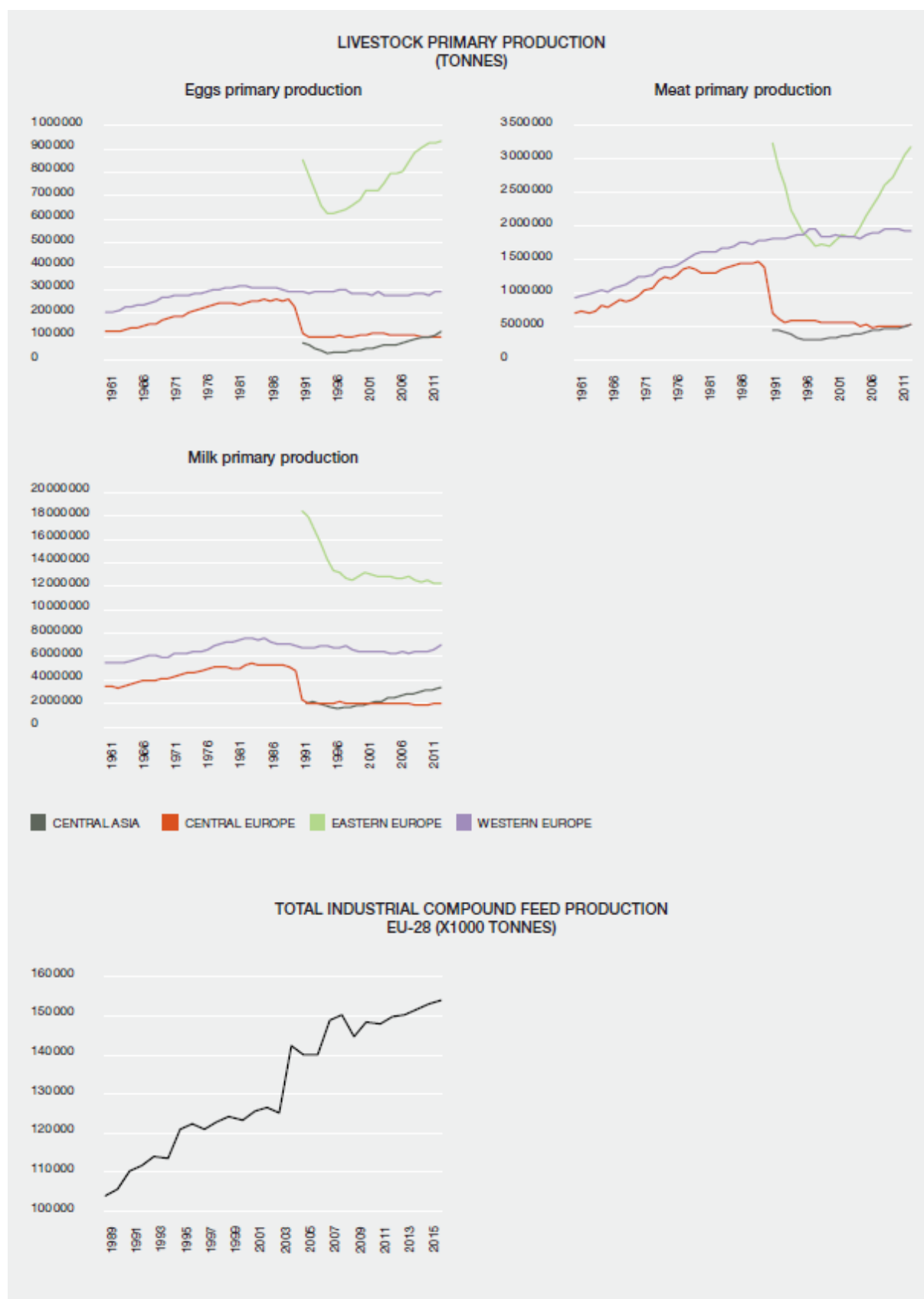


Figure 2.22: Historical trends for average country production of livestock primary production (tonnes) of eggs, meat and milk in the four subregions and total industrial compound feed in the EU-28. Own elaboration based on data from the Food and Agriculture Organization of the United Nations (FAO, 2017) and the European Feed Manufacturers' Federation (FEFAC).

3751 Cattle represent the largest share of livestock animals in Europe and Central Asia (see **Figure 2.23**). In
 3752 Central Asia, sheep account for about 25% and goats for about 6% of livestock production. In Central
 3753 Europe, pigs represent the second largest share (25% in 2013), but this has been decreasing since the
 3754 early 2000s. Chicken account for almost 20% in Eastern Europe, with rapid increases in recent decades.
 3755 Overall, the trend in the past decade is an increase in chicken production, maintenance of cattle
 3756 production, and reduction of pigs, goats and sheep (**Figure 2.23**).

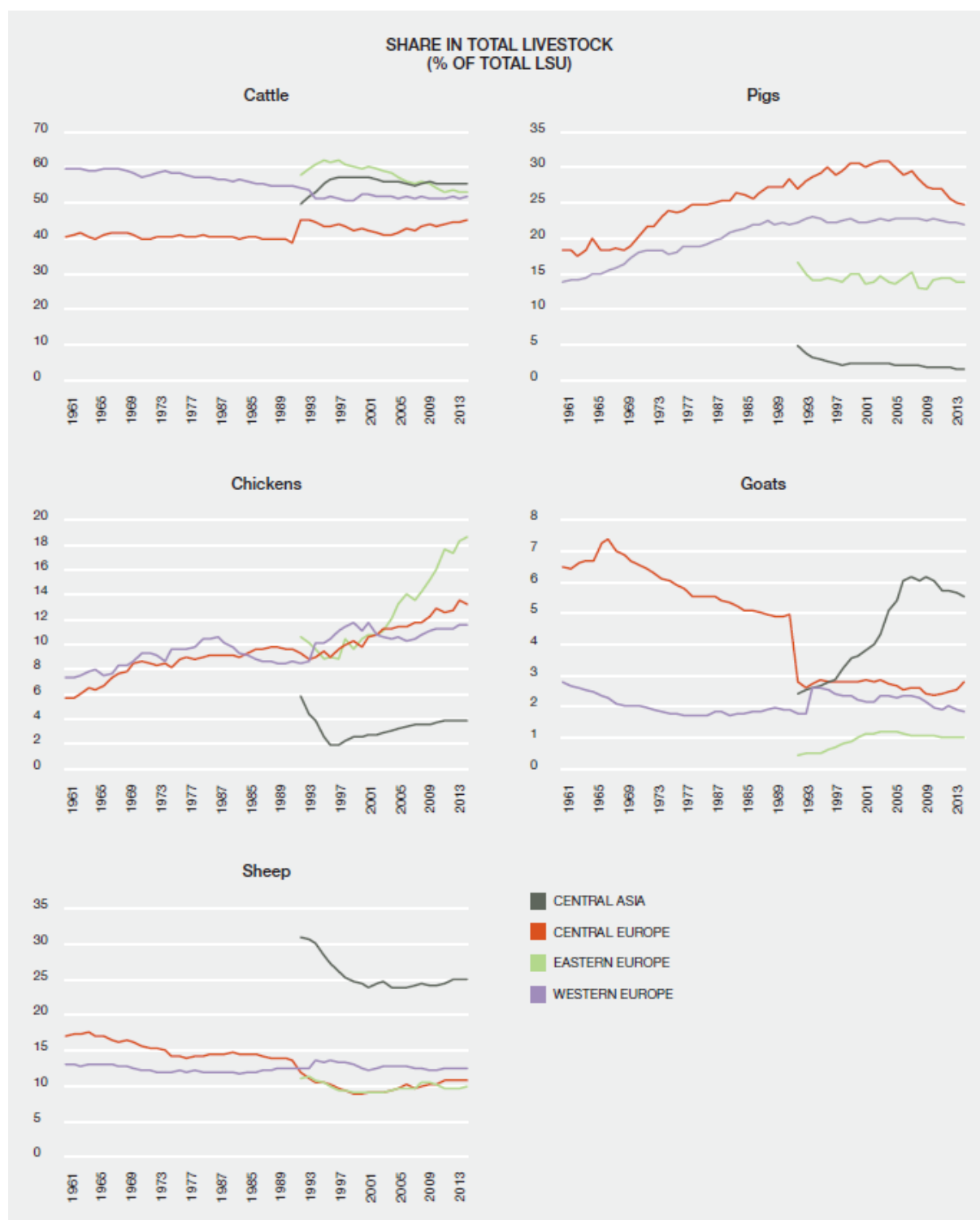


Figure 2.23: Historical trends in the share of total livestock represented by cattle, pigs, chicken, goats and sheep in the subregions. Own elaboration based on data from the Food and Agriculture Organization of the United Nations (FAO, 2017).

Forests provide nuts, mushrooms, herbs, spices, aromatic plants and game that have been used not only as food, but also for health and cultural purposes for millennia. Yet a recent report by the Food and Agriculture Organization of the United Nations acknowledges that there is a tendency to underestimate their role because they are poorly represented in international statistics, as in most cases their use and trade are confined to the informal sector (Sorrenti, 2017). However, recent studies show that non-timber forest products still form the basis of livelihoods and play a significant role in food, nutrition and as a source of income, particularly in times of deep economic crisis (e.g. Elbakidze et al. (2007)).

2.2.2.1.2 Wild capture and cultured aquatic food production

Fishing has a long, rich tradition in Europe and Central Asia (Ståhlberg & Svanberg, 2011), and is still an important source of protein for indigenous people (Demeter, 2016). Across Europe and Central Asia, aquatic ecosystems make an important contribution to people's diets, directly as food and as feed for livestock. The largest contribution of aquatic ecosystems is wild-captured seafood, especially from the highly productive North East Atlantic. Seafood production from this area is 8.9 million tonnes per year (production data from 2014, if not otherwise stated). Wild capture of seafood from the Mediterranean and Black Sea area (restricted to Europe and Central Asian fleets) is much smaller (0.5 million tonnes per year), even when taking the smaller size of this area into account. This is largely due to lower nutrient concentrations in the Mediterranean. In relation to primary production, fisheries are similarly productive in the Mediterranean and Black Sea as, e.g., in the North Sea (Libralato et al., 2008). A decline in production since the turn of the millennium (see **Figure 2.24**) is due to a transition to more sustainable management practices, after a phase of overexploitation where catch limits larger than those scientifically advised were regularly set (Carpenter et al., 2016; Hilborn & Ovando, 2014).

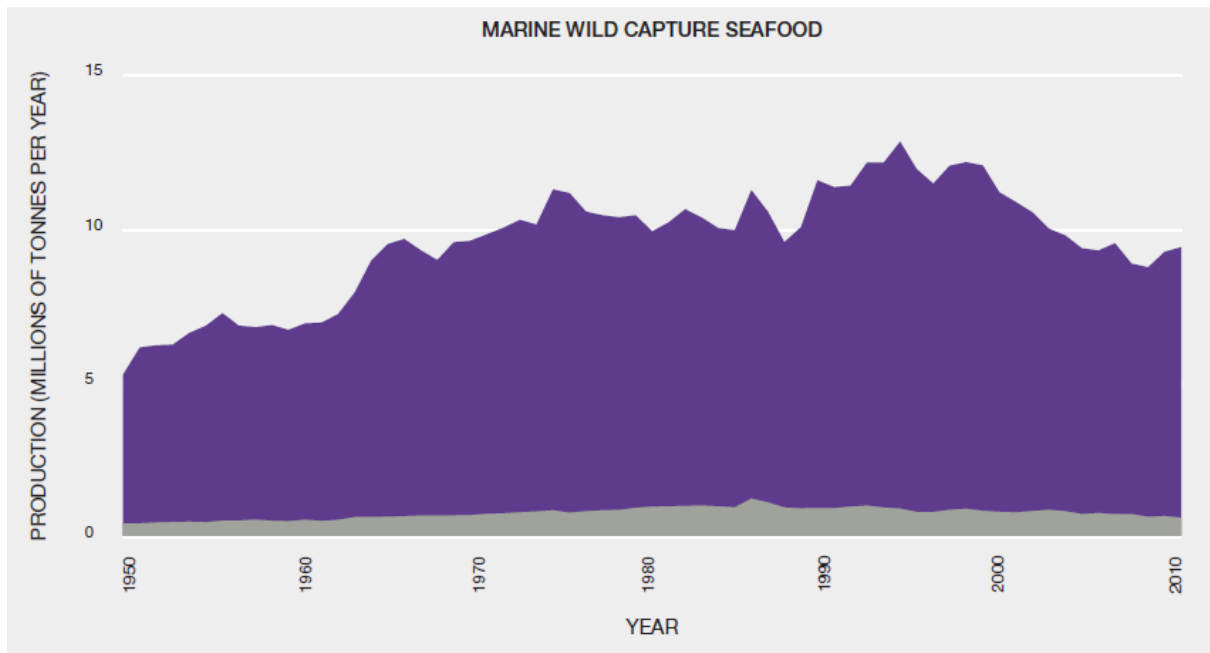


Figure 2.24: Marine wild-capture seafood production in seas surrounding Europe and Central Asia. Colouring indicates contributions from the North East Atlantic Ocean (FAO Area 27, violet) and Mediterranean and Black Sea (FAO Area 37, grey). Own representation based on data from the Food and Agriculture Organization of the United Nations (FAO, 2017).

Reported production of wild capture food from inland waters in Europe and Central Asia is dominated by freshwater (67%) and diadromous (31%) fisheries. Compared with marine production, wild capture food from inland waters is relatively small at 0.4 million tonnes per year, but it plays an important role especially in Eastern Europe and Central Asia, which are dominated by commercial fisheries (Aps et al., 2004). Data prior to 1988 are insufficient for a regional assessment, but, as **Figure 2.25** shows, production of wild capture food from inland waters in Europe and Central Asia fell from 1988 to 2005, but since then has grown slightly. The decline in production in Eastern Europe since 1988 until the turn of the millennium (**Figure 2.25**) has been attributed to the serious depletion of many open access freshwater fishery resources caused by overfishing and “insufficient control and enforcement (illegal and unreported catches do not appear in statistics)” (Aps et al., 2004).

Contrasting the situation for wild-capture fisheries, production from aquaculture has continuously increased since 1950, with the exception of a brief phase of contraction in Eastern Europe after the socioeconomic transformations around 1990 (see **Figure 2.26**). According to these data, production has grown at an average rate of 2.7% per year since 2000 and by 2014 reached 3.0 million tonnes per year. Salmon farming in northern parts of Western and Central Europe made an important contribution to this expansion. Overall, diadromous fish now contribute around 63% to total aquaculture production, followed by molluscs (21%), freshwater fish (10%) and marine (6%) fish. Despite this continuous rise in aquaculture production, Europe and Central Asia lags behind the global rate, where the proportion of aquaculture fish production now contributes 40% of production (FAO, 2014a). This indicates the potential for significant further expansion in Europe and Central Asia. However, as with wild-capture fisheries, aquaculture can have adverse environmental effects that might offset its benefits (Read & Fernandes, 2003).

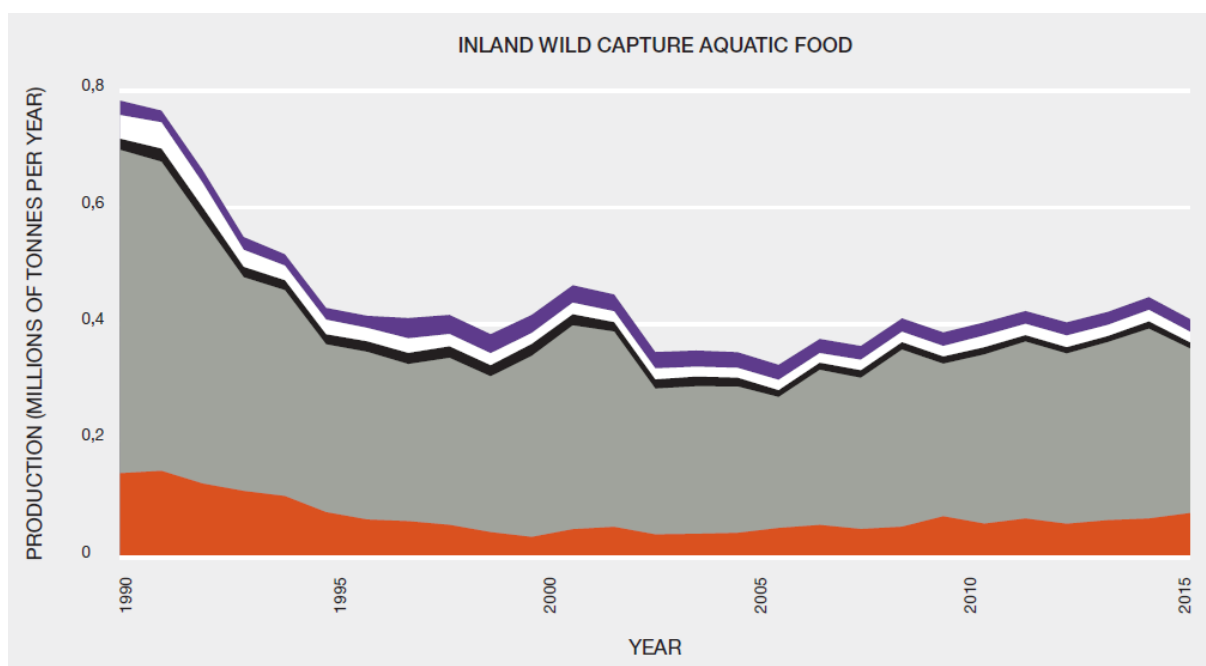


Figure 2.25: Inland wild capture production of aquatic food in Europe and Central Asia. Colouring indicates contributions from Central Asia (orange), Eastern Europe (grey), northern parts of Central Europe (black), southern parts of Central Europe (white), and Western Europe (violet). Own representation based on data from the Food and Agriculture Organization of the United Nations (FAO, 2017).

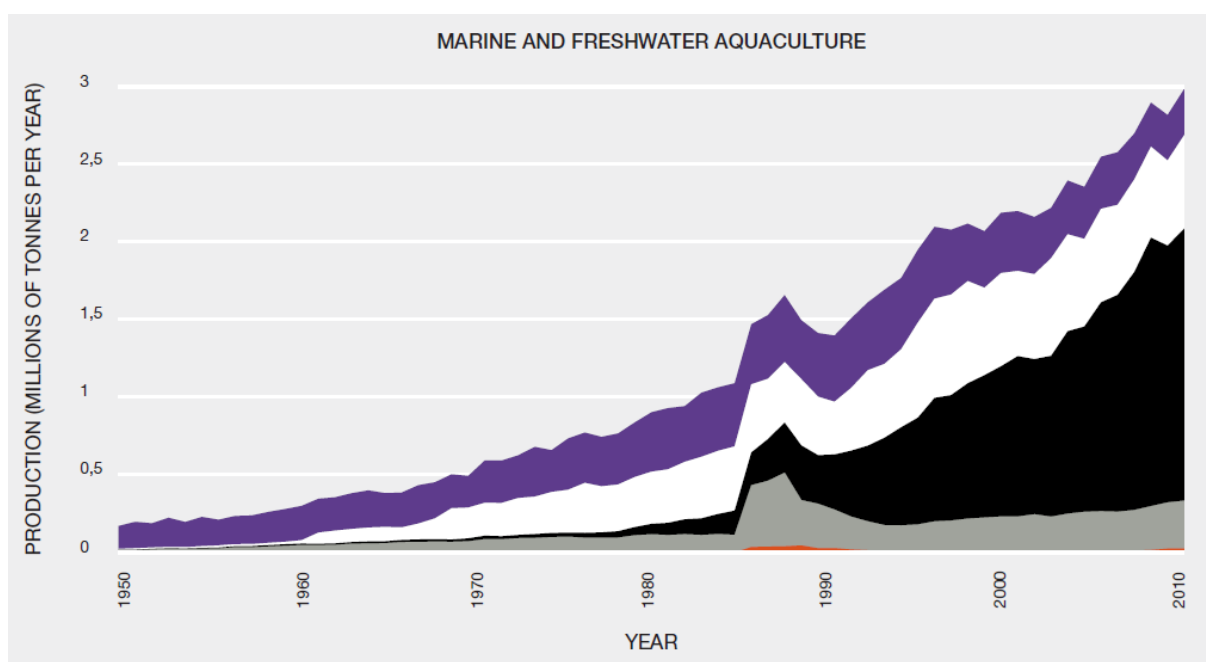


Figure 2.26: Aquaculture production in Europe and Central Asia. Colouring indicates contributions from Central Asia (orange), Eastern Europe (grey), northern parts of Central Europe (black) and southern parts of Central Europe (white), and Western Europe (violet). Own representation based on data from the Food and Agriculture Organization of the United Nations (FAO, 2017).

2.2.2.2 Energy

Various forms of biomass can serve as fuel including plants, animal dung, and agricultural residues. Plant matter is used directly or in processed forms such as charcoal and oil. Two forms of biomass-based energy are particularly relevant in Europe and Central Asia and therefore the focus of the following sections: woodfuel and biofuels.

2.2.2.2.1 Woodfuel

Woodfuel (including logs, charcoal, chips, bark, and sawdust) has a high energy density (comparative average values in MJ/kg - woodfuel: 16; charcoal: 28; coal: 30; natural gas: 37 and fuel oil: 4) (World Energy Outlook 2004, 2004). Its availability, accessibility and renewability make it attractive, especially in rural areas. According to statistics from the Food and Agriculture Organization of the United Nations, overall woodfuel production and consumption has been largely stable since 2000 (see **Figure 2.27**). Within Western Europe, woodfuel use is significant especially in Scandinavia. It is unclear whether the comparatively low woodfuel production in Central Asia according to statistics from the Food and Agriculture Organization of the United Nations (see **Figure 2.27**) (between 2000-2013 it varied between 190,000 and 1,000,000 m³ p.a.) is due only to biogeographic and climatic differences, or also due to underreporting.

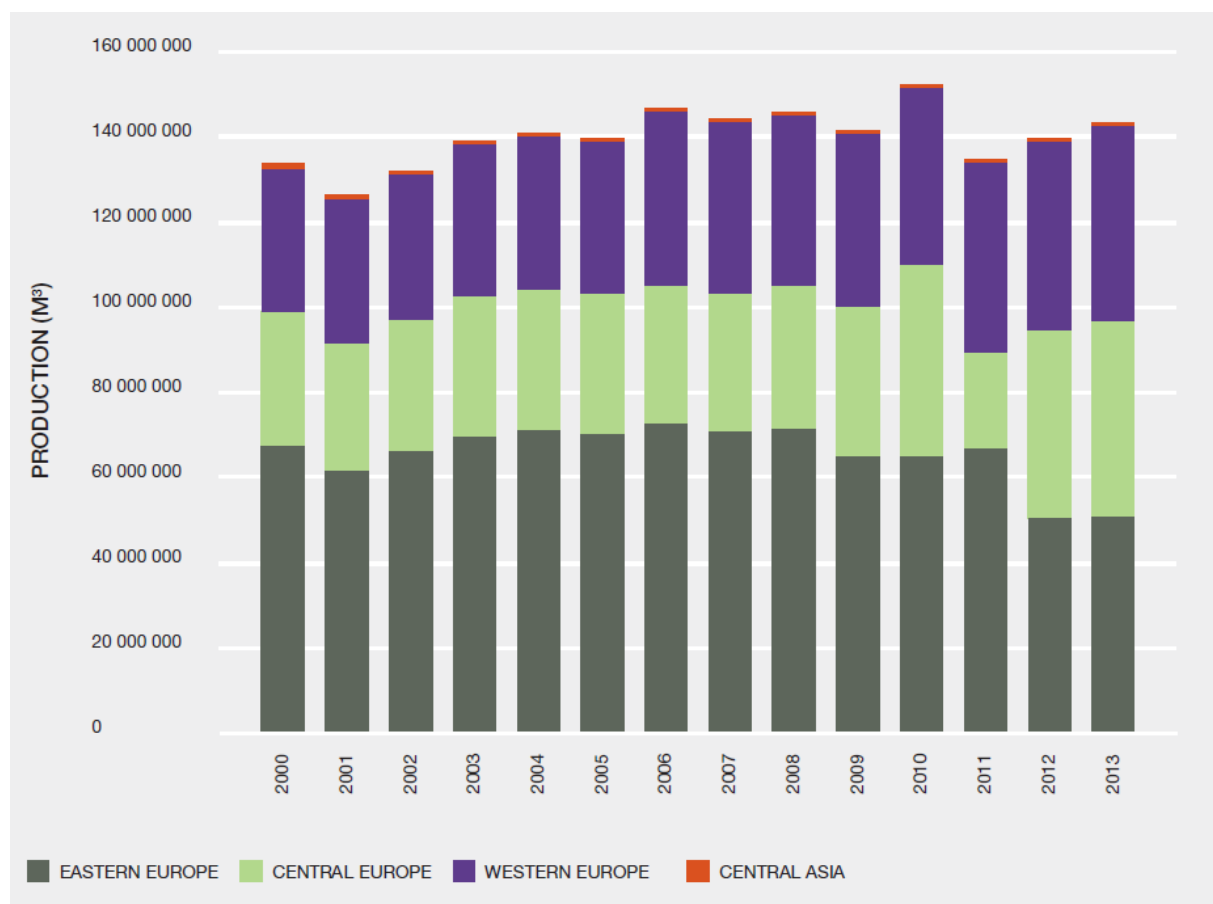


Figure 2.27: Woodfuel production in Europe and Central Asia between 2000 and 2013. Own representation based on data from the Food and Agriculture Organization of the United Nations (FAO, 2017).

Driven by the European Union's legally binding targets in the Renewable Energy Directive (RED - 2009/28/EC), production of renewable energy within the EU-28 almost doubled between 2004 and 2013. Based on Eurostat, in 2013, total biomass (woodfuel and other biomass including municipal waste) accounted for 65% of the gross inland energy consumption of renewables in the EU-28, of which wood and wood wastes contributed the highest share with 45%. Around 23% of the EU-28's total roundwood production of 425 million m³ in 2014 was used as woodfuel (Eurostat, 2017). Among the European Union member States, Sweden produced the most roundwood (70 million m³) in 2014, followed by Finland, Germany and France (each producing between 52 and 57 million m³). More than half of roundwood produced is used as fuel in Denmark, France and Cyprus (2013 and 2014), while Bulgaria, Croatia, Hungary and Lithuania reported proportions between 32 and 46%. However, direct woodfuel use by households is not included in these numbers, which is why they are likely to be underestimates.

In the European Union, woody biomass accounts for almost 50% of renewable energy consumption (Pelkonen et al., 2014). In some widely forested countries, large proportions of total energy consumption originate from forest biomass, for example 30% in Sweden (Hansen & Malmaeus, 2016) and 25% in Finland (Jäppinen & Heliölä, 2015). Due to a long-standing tradition of forestry and forest management in Western and Central Europe, deforestation driven by woodfuel and other wood product extraction is not currently a threat for the region (UNEP/UNECE, 2016). On the other hand, dependence on woody biomass as a source of domestic energy continues to be prominent especially in rural and economically disadvantaged communities in Europe and Central Asia. In Central Asian countries such as Tajikistan, deforestation continues and overuse of forests for fuel is one of the main reasons for land degradation (Mustaeva et al., 2015). In the Balkans and the South Caucasus, wood remains an important affordable energy source (Adeishvili, 2015). In Albania, for instance, firewood meets one-third or more of the total energy demand for heating and accounts for almost 90% of wood use (Markus-Johansson et al., 2010). In certain areas of Europe and Central Asia, restraining economic conditions lead to considerable illegal woodfuel harvesting. In Turkey, for example, off-the-record logging for woodfuel (estimated 4,300,000 m³) reached more than half the permissible woodfuel harvests (7,000,000 m³) in 2010 (Pak et al., 2010). In the Ukraine, the economic recession and the gas crisis caused by the Russian-Ukrainian conflict is reported to have significantly increased firewood thefts (Roue & Molnar, 2016).

Woody biomass demand from countries with ample forest resources such as Sweden and Finland is foreseen to increase (Jonsson, 2013) and generally in Western, Central and Eastern Europe the shift towards a carbon neutral society is expected to further boost the demand for woodfuel (Bostedt et al., 2016). This intensification of biomass removals from forests may have trade-offs in forest productivity, biodiversity and soil quality (Bouget et al., 2012; Verkerk et al., 2014).

Historically, woodfuel collection is among the earliest uses of forests by humans (Pelkonen et al., 2014). Local ecological knowledge related to forest management is just as rooted in Europe and Central Asia as woodfuel utilization. An example from the communities inhabiting the lowland landscapes of Transcarpathian region *Zakarpats'ka oblast'* in western Ukraine points to a tradition of accessing firewood as dry wood and during forest logging (Roue & Molnar, 2016). The locals state the need for young forest stands in addition to old, diverse structured forests: *"For firewood we went only here, on the Lapos. That was the closest, and there was thin, dry wood, which could be broken by hand."* (ibid) (See electronic Appendix 2. 2).

2.2.2.2.2 Provision of biofuels

The term “biofuel” generally refers to liquid transportation fuels made from biomass materials, such as ethanol and biodiesel. Biofuel production rose by a factor of ten between 2000 and 2014 in Western Europe (Figure 2.28). Simultaneously, imports increased both in Central and Western Europe, but the import dependence was much higher in Central Europe. Central Asia and Eastern Europe had only a negligible share (Figure 2.28). In terms of energy content, current annual production of biofuel (Figure 2.28) remains small compared to that of woodfuel (140,000,000 m³ correspond to 1,000,000 – 2,400,000 tJ energy).

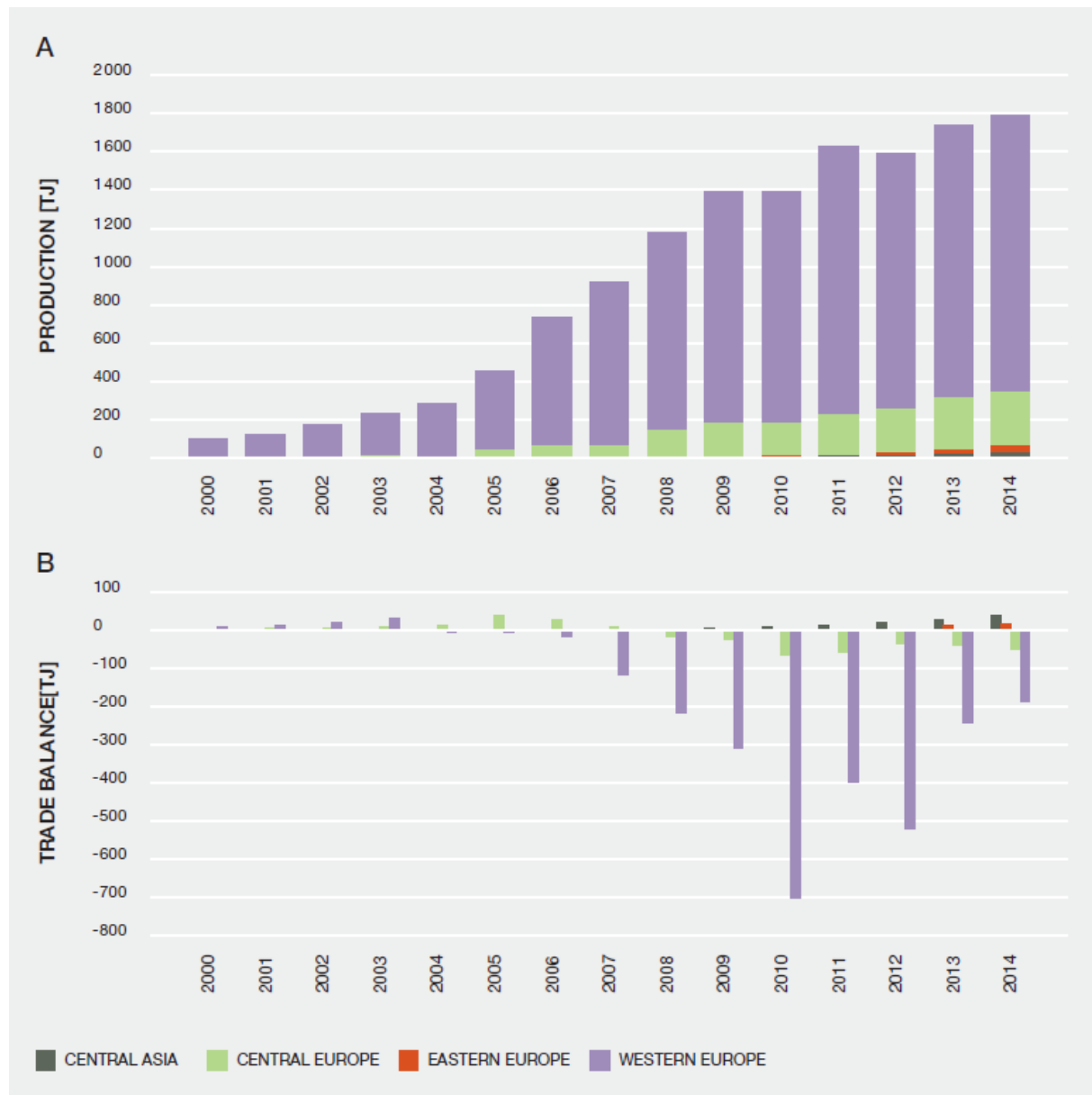
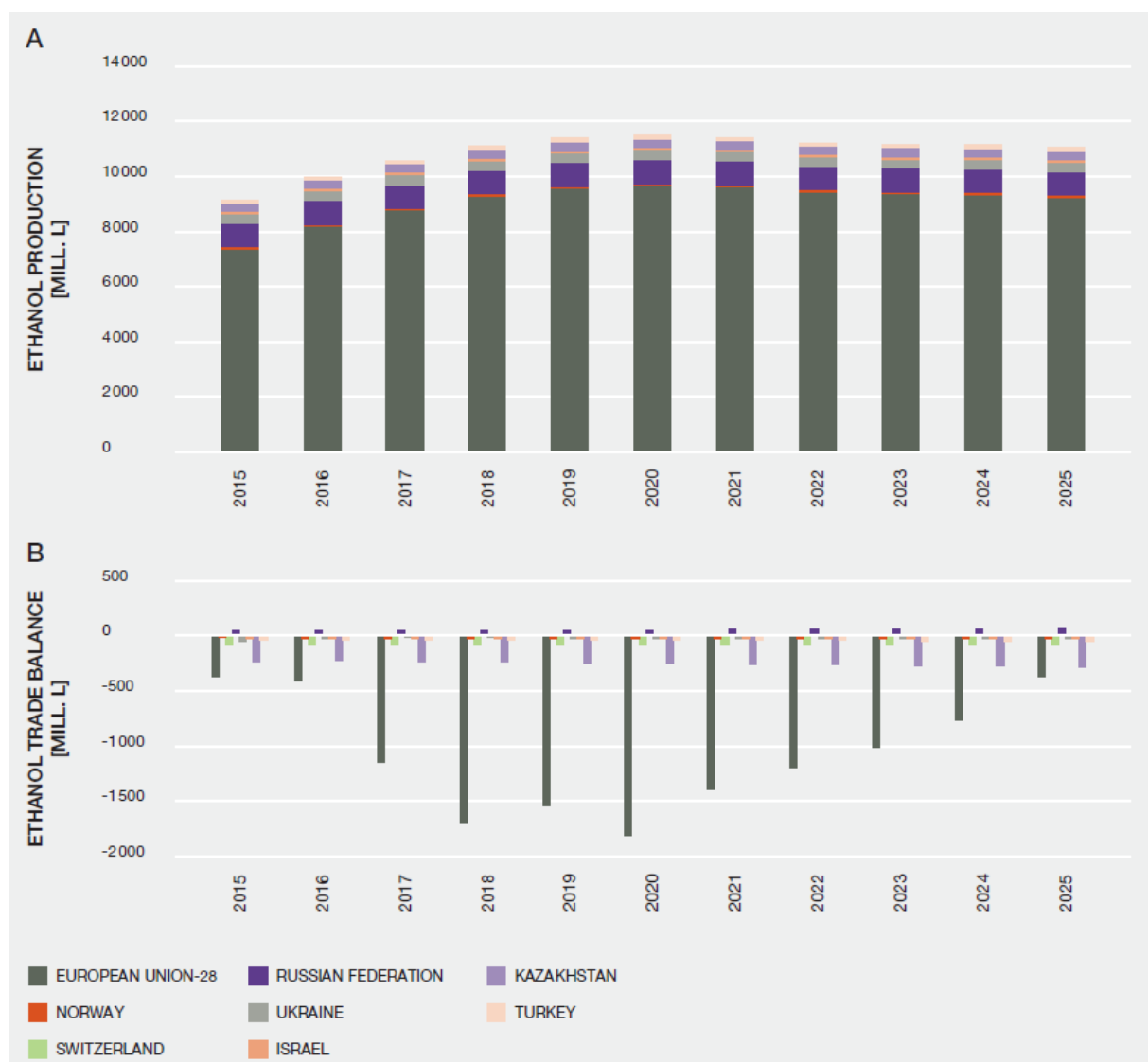


Figure 2.28: (A) Biofuel production by regions in Europe and Central Asia from 2000 to 2014. (B) Trade balance of biofuels by regions in Europe and Central Asia from 2000 to 2014. Own representation based on: (U.S. Energy Information Administration, 2017).

An outlook for Europe and Central Asia shows a slight increase in ethanol production until 2020, which is expected to become stable by 2025 (Figure 2.29). For biodiesel, production is expected to peak by 2019 and to decline until 2025. The EU-28 as major producer is equally a major consumer with a

strongly negative trade balance for both ethanol and biodiesel production. It is expected to roughly equalize until 2025. Only for Kazakhstan, a continuously negative trade balance for ethanol is expected. However, impacts of the production of energy crops on the environment and on other contributions from nature to people limit their use (Meyer & Leckert, 2017). Major concerns exist concerning the potential of GHG emission offset, regulation of soil quality, water quality and quantity, biodiversity, and indirect land-use change that displaces ecological impacts outside of the biofuel production region (Efroymson et al., 2013; McBride et al., 2011). These trade-offs could be considered in policy by implementing, for instance, stricter rules for biofuel certification that consider the environmental and social impacts within and beyond the feedstock production region (Meyer et al., 2016).

In the future, agricultural residues, as one example of second-generation biofuel feedstocks, can also contribute substantially to energy production. Studies for the European Union consider that around 25 to 60% of agricultural residues could be available for this purpose (Bentsen & Felby, 2012).



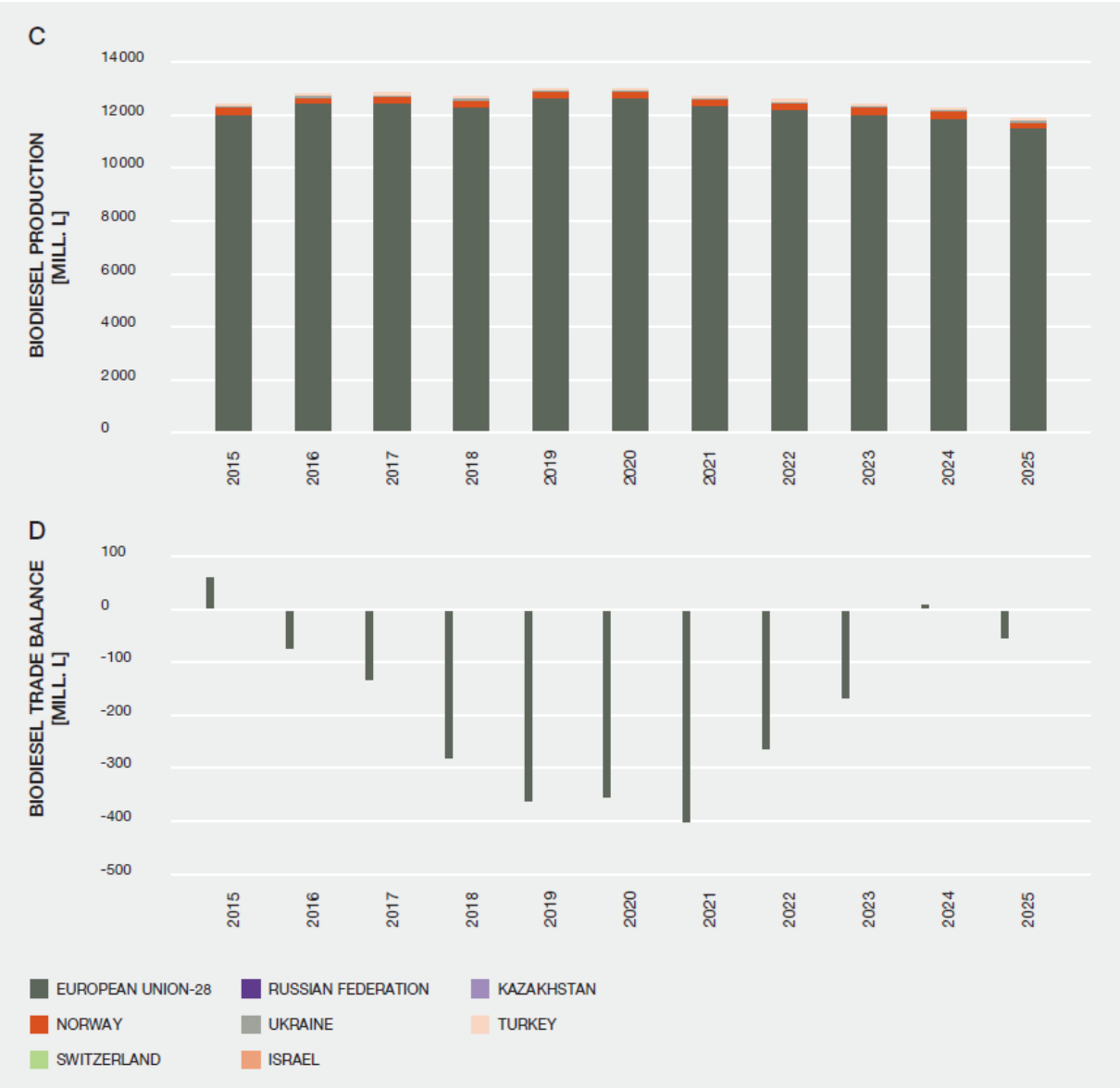


Figure 2.29: (A and C) Biodiesel and ethanol production in selected countries in Europe and Central Asia from 2015 to 2025. (B and D) Trade balances of biodiesel and ethanol in selected countries in Europe and Central Asia from 2015 to 2025. Own representation based on: (OECD-FAO, 2016).

2.2.2.3 Materials and assistance

Nature contributes to people’s quality of life by providing materials for construction, clothing, ornamental purposes, or assistance for herding, guidance and guarding (IPBES, 2017a). For most of these materials, comprehensive national or sub-national level data do not exist, with the exception of wood. Here, we present the status and trends of this contribution from nature to people in Europe and Central Asia associated with the provision of wood, cotton, and other vegetal materials, materials from marine systems and the assistance of dogs in guarding and protecting livestock.

2.2.2.3.1 Provision of wood

Roundwood is defined as all wood removed with or without bark, including wood removed in its round form or in other forms (FAO, 2015a). Roundwood can be subdivided into industrial roundwood, used mainly for construction and in processed timber products, and woodfuel (see Section 2.2.2.2.1). Total production of roundwood has remained stable in Europe and Central Asia (FAO, 2015a), with a major impact by the fall of the iron curtain (**Figure 2.30**) and a slight decline for the period 2005-2014 in Western Europe (**Figure 2.31**). Timber standing stock, regardless of use or degree of management, are largest in some regions of Western and Central Europe: forests of Central Europe, Scandinavia and the Alps (**Figure 2.32**).

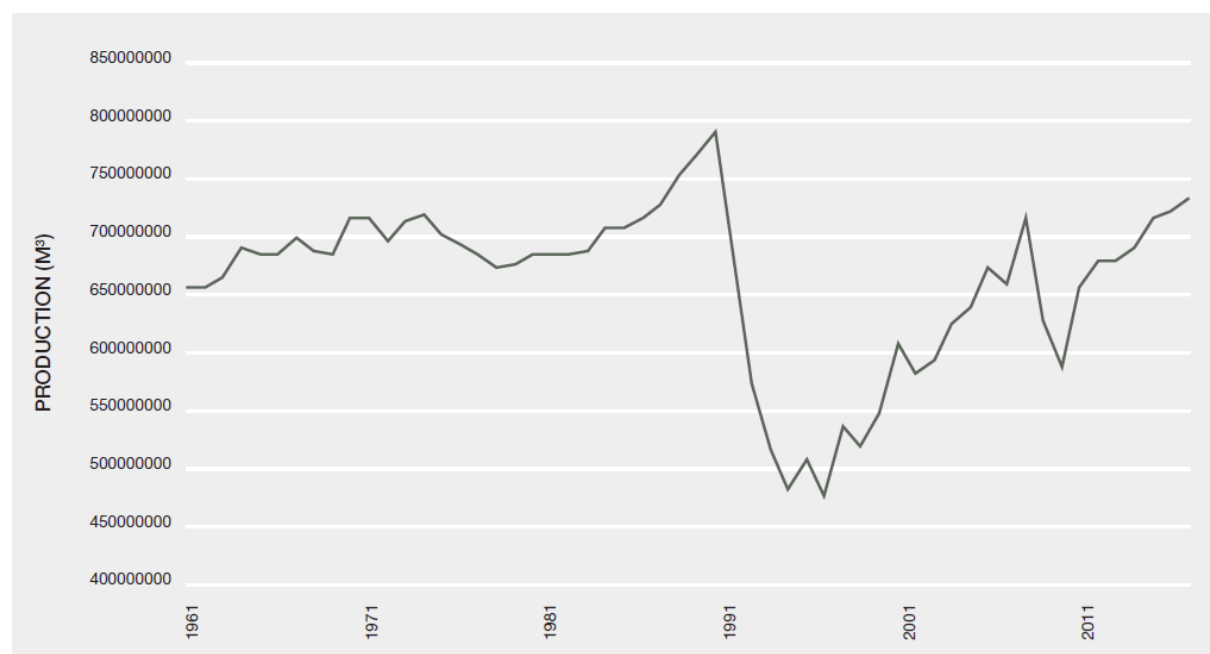


Figure 2.30: Annual production of roundwood in Europe and Central Asia, 1961-2014 in cubic metres (FAO, 2017).



Figure 2.31: Annual roundwood removal in Western, Central and Eastern Europe (for Eastern Europe only data for the Russian Federation is available) in 1,000 m³. Own representation based on Eurostat.

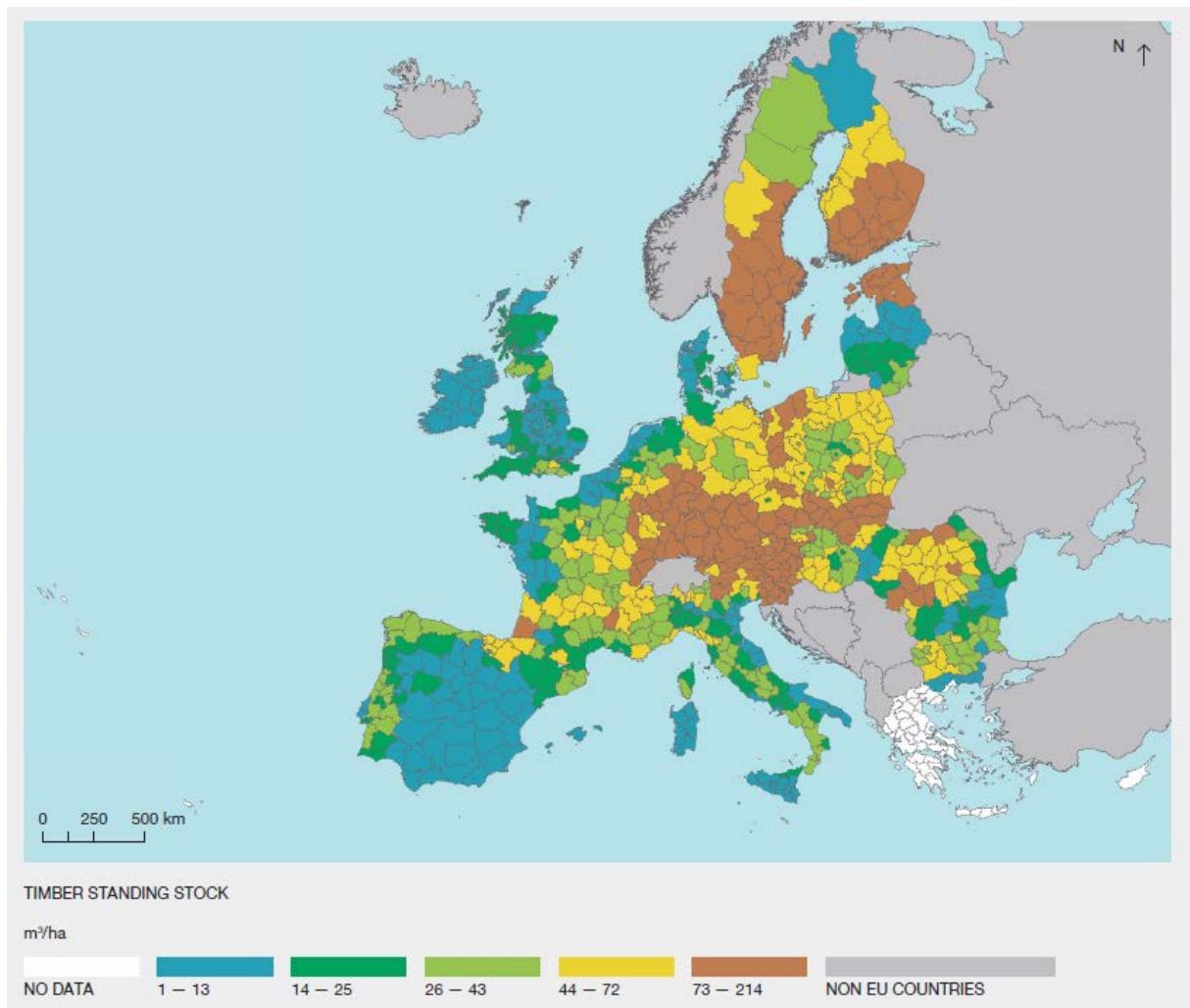


Figure 2.32: Density of timber stock (all uses) in European Union countries (Source: European Commission, 2011)

2.2.2.3.2 Cotton and other vegetal materials

During the period 1961-2014 cotton lint was mostly produced in Central Asia and Turkey. Production in Central Asia has fluctuated without a clear trend (**Figure 2.33**), masking marked technological, economic and political transformations of the cotton industry (Kandiyoti, 2007).



Figure 2.33: Annual production of cotton lint in Central Asia, 1992-2014, in tonnes (FAO, 2017).

Reed has traditionally been used in many regions for thatching, but it can be also be utilized in a number of other ways, including in construction and gardening, in paper, textile and plastic production, and as fodder and fertilizer (Köbbing et al., 2013). Reed is grown and harvested throughout the subregions (Köbbing et al., 2013). Mediterranean countries of Europe play an important role in the provision of cork, as they produce 87% of cork globally, especially the Iberian Peninsula, which is home to the majority of cork oak (*Quercus suber*) forests in the world (Acácio & Holmgren, 2014; Boschmonart, 2011) and, therefore, also cork extraction (Figure 2.34). About 70% of harvested cork is used for the production of bottle stoppers. Other products include flooring, insulation material, clothes and accessories, and decorative objects (Bugalho et al., 2011).

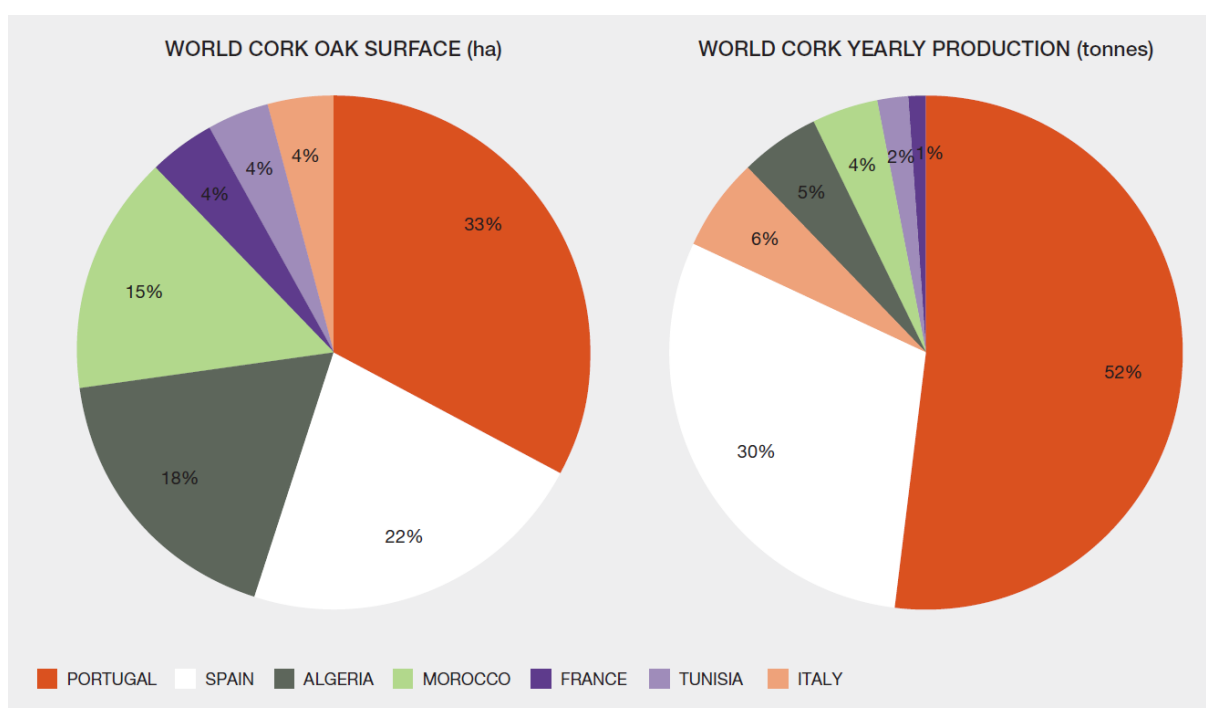


Figure 2.34: Cork oak distribution in the western Mediterranean. Source: Boschmonart (2011)

Rosins are solid forms of resins obtained from pine trees and some other conifers. They are extracted by tapping the tree (Mitchell et al., 2016). Historically used to waterproof ships, they are now used in

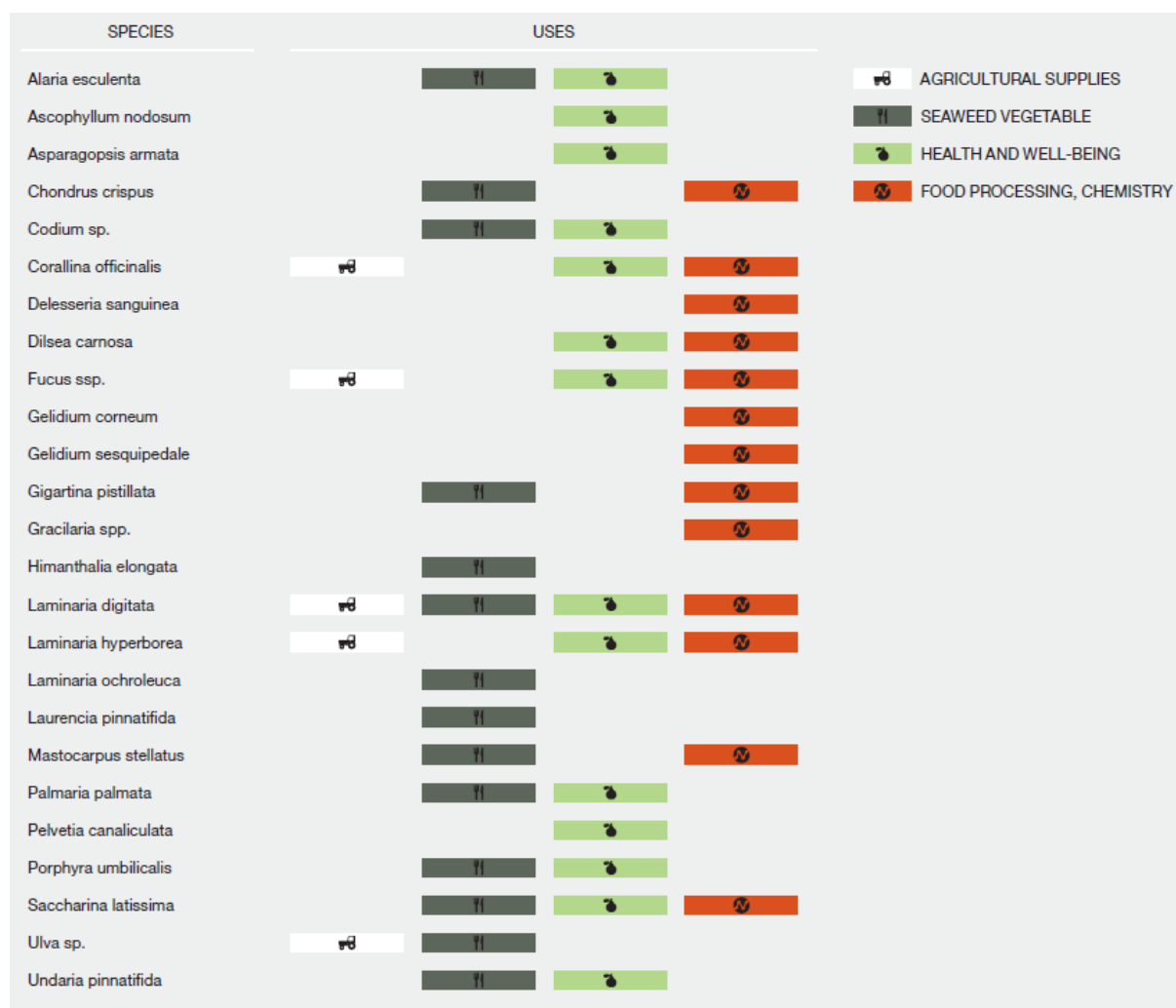
the production of chemicals, paints, inks, varnishes, floor coverings and soaps. Sources of rosins in Europe and Central Asia are *Pinus pinaster* (Portugal), *P. sylvestris* (former Soviet Union), *P. halepensis* (Greece) and *P. brutia* (Turkey) (FAO, 1995).

Only a few countries in Europe and Central Asia produce turpentine and resin, with decreasing trends due to the high costs of labour. Portugal accounts for the majority of world trade in gum turpentine, but production fell from an average of 110,000 tonnes per year during 1978-1987 to 30,000 tonnes by 1992 (FAO, 1995). Minor production is also reported in Central and Eastern Europe (FAO, 1995). Recently, new uses of pine resin in polymers have emerged (Wilbon et al., 2013).

2.2.2.3.3 Materials from marine ecosystems

Marine ecosystems provide a wide range of materials for different uses, including algae maerl, seaweed fishmeal, fish oil (used in textile production, metallurgy, production of detergents, paints and resins), shellfish and molluscs for ornamental purposes (Murillas-Maza et al., 2011). Seaweed and kelp species are used in various ways in Western Europe (**Figure 2.35**). Kelp is now particularly used for extraction of alginates, which are used in the food processing industry, as well as in the production of textiles and pharmaceuticals (Netalgae, 2012; Smale et al., 2013). France and Norway are the main producers of kelp in Western Europe with annual production of about 50,000 tonnes of *Laminaria digitata* in France and about 200,000 tonnes of *L. hyperborea* in Norway (Smale et al., 2013). In Western Europe, production of macroalgae has decreased in the last 10 years (Bioforsk, 2012).

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3992

3993 **Figure 2.35: Main uses of macroalgae in Europe. Source: Netalagae (2012).**

3994 Maerl is a collective term for various species of non-jointed coralline red algae (family
 3995 Corallinophycidae) that live unattached to the seabed. Maerl has been dredged in the European Union
 3996 for use as an agricultural soil conditioner and for use in animal and human food additives, water
 3997 filtration systems, and pharmaceutical and cosmetic products. By the 1970s extraction peaked with
 3998 about 600,000 tonnes per year in France¹⁸; however, due to their very slow growth, maerl beds have
 3999 declined throughout the North East Atlantic and are classified as Vulnerable on the European Union
 4000 Red List (European Commission, 2016a).

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2.2.2.3.4 Assistance of livestock protection and guard dogs

4003 For centuries guard dogs have helped shepherds protect their livestock from predators, specifically
 4004 brown bears (*Ursus arctos*) and wolves (*Canis lupus*), in Central Europe and Central Asia (Gehring et
 4005 al., 2010; Linnell & Lescureux, 2015). With the decimation of these predators in Western Europe and
 4006 the collectivization of agricultural policy under communist regimes, much of the indigenous and local
 4007 knowledge about the use of guard dogs was lost (Gehring et al., 2010; Linnell & Lescureux, 2015).
 4008 However, with the recent recovery of large carnivores in continental Europe (Chapron et al., 2014),

¹⁸ <http://forum.eionet.europa.eu/european-red-list-habitats/>

guard dog use is being suggested as a means of facilitating human-carnivore coexistence (Linnell & Lescureux, 2015). Indeed, more than 1,000 dogs are now used in the Alps for this purpose (Gehring et al., 2010). Indigenous peoples and local communities value them, as a herder explains: “No, the beasts are no real problem for us, we have our dogs and sticks, we are not afraid of wolves and bears” (herder; (Ivascu & Rakosy, 2016)) (see electronic Appendix 2.2). Guard dogs in Europe and Central Asia hold substantial identity value among shepherds and breeds are closely linked to specific areas (**Figure 2.36**) (Linnell & Lescureux, 2015).



Figure 2.36: Breeds of guard dogs identified in Europe and Central Asia. Source: Linnell & Lescureux (2015).

2.2.2.4 Provision of Medicinal resources

The value of biodiversity as a resource for the production of medicines is one of the clearest examples of the relationships between nature and human health. Numerous species of plants, animals and fungi have been used to produce traditional therapies since ancient times, and wild flora and fauna continue to support the development of modern pharmaceutical products. This section considers medicinal plants in Europe and Central Asia, which form part of traditional and local medicinal practices, as well as medicinal plant products, which are sold commercially, and their use in modern pharmaceutical development. It covers plants, which are harvested directly from the wild, as well as those that are grown in home gardens or cultivated commercially. For the assessment of this contribution from nature to people, in addition to the literature review undertaken in this chapter (electronic Appendix 2.1), we also conducted an expert¹⁹ elicitation on the basis of several key messages. The original key messages and the results of the expert elicitation are provided in electronic Appendix 2.5.

¹⁹ Eighteen experts from the different biodiversity and health networks (such as the Belgian Community of Practice Biodiversity & Health (COPBH) and its international connections, Co-operation on Health and Biodiversity (COHAB), ESP thematic working group on health, Network for Evaluation of One Health (NEOH) and contact authors of publications found in the literature review conducted for this contribution from nature to people.

Nature's capacity to provide medicinal plant resources depends on the species richness of medicinal plants. Several areas in Europe and Central Asia are characterized by high medicinal plant species richness, including the Mediterranean region, the Alps and the Pyrenees, the Massif Central in France, the Balkan Peninsula, the Crimean Peninsula and the Carpathian Mountains (**Figure 2.37**) (Allen et al., 2014). However, some of these medicinal plants are threatened due to unsustainable patterns of exploitation (Allen et al., 2014). Land development and land use change are the next greatest threats, with residential and commercial development and agricultural practices also having important impacts. In Central Asia, intensified agricultural practices, loss of indigenous knowledge, and climate change have also been identified as significant threats to medicinal plant diversity (e.g. Bocharnikov et al. (2012; Breckle & Wucherer (2006; Haslinger et al. (2007) (see electronic Appendix 2.5). Consequently, collection of plants from the wild and loss of habitat due to physical development and land use change are the most significant threats affecting medicinal plants in the region.

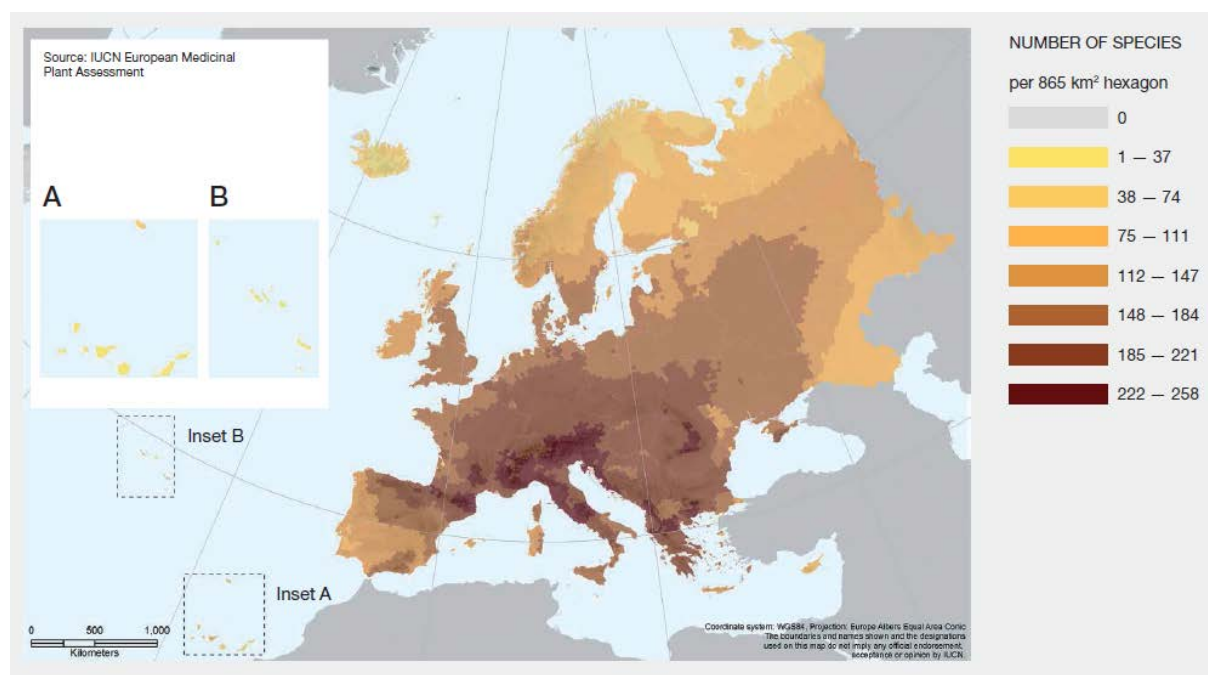


Figure 2.37: Species richness of selected medicinal plants in the European Union. Source: Allen et al. (2014)

Indigenous and local knowledge plays an essential role in creating greater understanding of the potential contributions of many plant species to human health. The importance of biodiversity-derived medicines has been widely noted, with a significant number of commercially available pharmaceutical products being derived from compounds identified in biodiversity (e.g. Bernstein (2015)). The World Health Organization estimates that 70-80% of the global population depend on some form of indigenous and local medicinal knowledge for their primary health care (Ekor, 2013). In addition, indigenous and local knowledge has been a source of interest and inspiration for modern drug development for several decades (see also Section 2.2.3.4); at the same time, various ethical issues associated with bioprospecting and biopiracy have been raised. These issues appear to be less significant in Europe (Efferth et al., 2016) (electronic Appendix 2.5).

Despite the importance of indigenous and local knowledge, there is a rapid rate of decline of traditional medical knowledge in Europe and Central Asia. In our fast-changing environment, especially related to increasing urbanization and changing agricultural practices, many traditions are disappearing from rural areas, with a profound loss of indigenous and local knowledge, particularly

among the younger generations (see Section 2.2.3.1). This decline has been highlighted by several scientific studies (e.g. Quave et al. (2012); Sánchez-Mata et al. (2016)). In some regions of Western and Central Europe, direct links have been identified between disappearing traditional farming systems and the decline in biodiversity of medicinal plants. On the other hand, there has been renewed interest in preserving traditional forms of knowledge about medicinal plants in the face of societal change and globalization as a form of cultural heritage (Pardo-de-Santayana et al., 2010).

Recent decades have also seen an increase in the use of medicinal plants as complementary, non-conventional or alternative forms of medicine (Barata et al., 2016; Roberti di Sarsina, 2007). Reasons cited for this increased attention have included public desire for affordable health remedies, and a perception that “natural” products are somehow safer and more effective than mainstream medicines. These factors have stimulated a rapid expansion of commercial markets for these remedies (FAO, 2005; Leonti & Verpoorte, 2017). The commercialization of traditional medicines and medicinal indigenous and local knowledge has seen many of these remedies moving from traditional practices to health and other markets.

Migrant populations moving into Europe and Central Asia from other regions have also brought their own traditional knowledge and related medicinal practices with them. Evidence suggests that these communities rely largely on plants and plant products imported from their home countries rather than alternatives that occur naturally in their new home regions (Pieroni et al., 2013; Quave et al., 2012) (electronic Appendix 2.5). This raises a number of further issues for conservation and public health, including those related to the collection, importation, sale and use of plants across borders outside of normal regulatory frameworks. While it appears that migrants prefer medicinal plants and related products imported from their home regions to local native alternatives, increasing demand may see alternative plant species being sought in migrants’ new home environments, presenting a further challenge for the sustainable exploitation of living resources. Therefore, because of increasing migration into Europe and Central Asia from other regions, there is an urgent need to increase the understanding of traditional medicinal practices within national public health care systems.

In addition to their potential role in supporting public health, traditional medicines may provide other social and economic benefits. Research in Tajikistan and Afghanistan has indicated that the use of medicinal plant species contributed significantly to local health sovereignty and security (see Section 2.3.2), which was particularly important during a period of social and political instability (Kassam et al., 2010). From a public health perspective, it appears important to ensure that traditional medicinal practices, which do not use marketed products but instead rely directly on harvested plants, are recorded and assessed, and to engage with practitioners to explore and communicate on issues of safety and efficacy.

2.2.3 Status and trends of nature’s non-material contributions to people

2.2.3.1 Learning and knowledge generation

2.2.3.1.1 Formal learning and knowledge generation

Nature benefits people by contributing to learning processes that inspire people and allow them to acquire knowledge and to develop skills. These benefits can occur through formal institutions, informal learning and at all levels of education (Angelstam et al., 2013; Anic et al., 2012; Mocior & Kruse, 2016). There are contrasting trends across these benefits. Formal learning linked to nature has increased recently, partly as a result of new learning and knowledge development processes linked to sustainable environmental management. Informal learning that draws on nature has also expanded

due to the increases in recreation and tourism (see Section 2.2.3.2), especially in protected areas promoting education and learning (Angelstam et al., 2013; Smrekar et al., 2016; Zedler, 2017). Some informal forms of learning and knowledge generation based on nature are in decline, particularly linguistic diversity which has traditionally been shaped by biodiversity and features of the natural environment (Section 2.1.1.1.2 Gorenflo et al, 2012; Maffi, 2005). The interactions between language and nature mean that a decline in linguistic diversity will be accompanied by a reduction in the variety of ways people communicate about aspects of nature and biodiversity (Harmon & Loh, 2010).

Formal learning in outdoor spaces has grown as national education systems have expanded. Formal learning provides additional benefits for learners and teachers in terms of cognitive outcomes, critical thinking, inspiration, observation skills and engagement with nature (Bizikova et al., 2012; Mocior & Kruse, 2016; Schlegel et al., 2015). Adults who have learned about sustainable development at school, or informally through activities such as gardening, may perceive their living space in a manner that is conducive to more sustainable lifestyles (Bendt et al., 2013; Breuste & Artmann, 2015; Fridl et al., 2009).

People using natural environments for recreational experiences also learn from each other. For example, a survey of 1,300 marine divers and recreational anglers in the UK showed that the sharing of knowledge and experience with others was a valued cultural ecosystem service (Jobstvogt et al., 2014). Learning benefits linked to inspiration from nature were also found in a survey of 291 people in Turkey (Fletcher et al., 2014). In Spain a survey of 1,400 people revealed that environmental education was a preferred ecosystem service for a large proportion of respondents and environmental education was viewed as a more important cultural ecosystem service than aesthetic values and recreational hunting (Martin-Lopez et al., 2012). Also in Spain, a survey of 198 beneficiaries of the largest park in Barcelona found that environmental learning was a perceived benefit of the park of low monetary value, but of high non-monetary value (Langemeyer et al., 2015).

2.2.3.1.2 Indigenous and local knowledge

Local ecological knowledge has been increasingly documented in Western, Central and Eastern Europe, particularly around its role in sustainable management of nature's contributions to people, its contribution to ecosystem restoration and its role in building social-ecological resilience (Carvalho & Frazão-Moreira, 2011; Hernández-Morcillo et al., 2014; Molnar et al., 2016). Overall, local ecological knowledge in Western, Central and Eastern Europe has eroded in recent decades, something acknowledged in the scientific literature as well as by the indigenous and local knowledge holders (see electronic Appendix 2.2). Significant losses of indigenous and local knowledge were found in Western Europe in agrobiodiversity management (Iniasta-Arandia et al., 2014; Kizos et al., 2013; Reyes-García et al., 2015), in forest management (Johann, 2007; Rotherham, 2007), and in pastoralist systems (Fernández-Giménez & Fillat Estaque, 2012; Oteros-Rozas et al., 2013b). Evidence of erosion of indigenous and local knowledge was also found in Central Europe, associated with agrobiodiversity management (Šmid Hribar & Urbanc, 2016), pastoralism (Lozej, 2013; Otčenášek, 2013) and medicinal plants and wild food plants (Łuczaj et al., 2012; Pardo-de-Santayana et al., 2010; Pieroni et al., 2013). However, some research has found stable patterns in indigenous and local knowledge associated with wild food plants and mushrooms in Central Europe (Łuczaj et al., 2015; Pieroni et al., 2013). In Eastern Europe, a decline in indigenous and local knowledge has been found in wood-pastures (Varga & Molnár, 2014), pastoralist systems (Kikvidze & Tevzadze, 2015; Lavrillier et al., 2016), and the indigenous and local knowledge associated with wild food (Łuczaj et al., 2013).

The erosion of indigenous and local knowledge also involves the loss of linguistic diversity as indigenous and local languages represent the reservoirs of considerable knowledge about non-human species and their relationships with the environment (Nabhan, 2001). The endangerment level of indigenous and local languages in Europe and Central Asia is critical (see **Figure 2.38**). While a large number of these languages are extinct²⁰ (12% of total languages) or critically endangered²¹ (11%), 14% still remain alive as most children speak the language (vulnerable category). The level of endangerment varies across subregions (see **Figure 2.38**). While Central Asia has no languages under the categories of extinct and critically endangered, 31% and 24% of languages in Eastern Europe and Central Europe, respectively, are classified as extinct or critically endangered. Despite this level of threat, it is noticeable that the trends of the Index of Linguistic Diversity for indigenous languages in Eurasia between 1970 and 2005 is rather stable (with a slight decline from 1990) (see **Figure 2.39**) because Western and Central Europe might have lost the majority of its linguistic diversity prior to 1970 (Harmon & Loh, 2010).

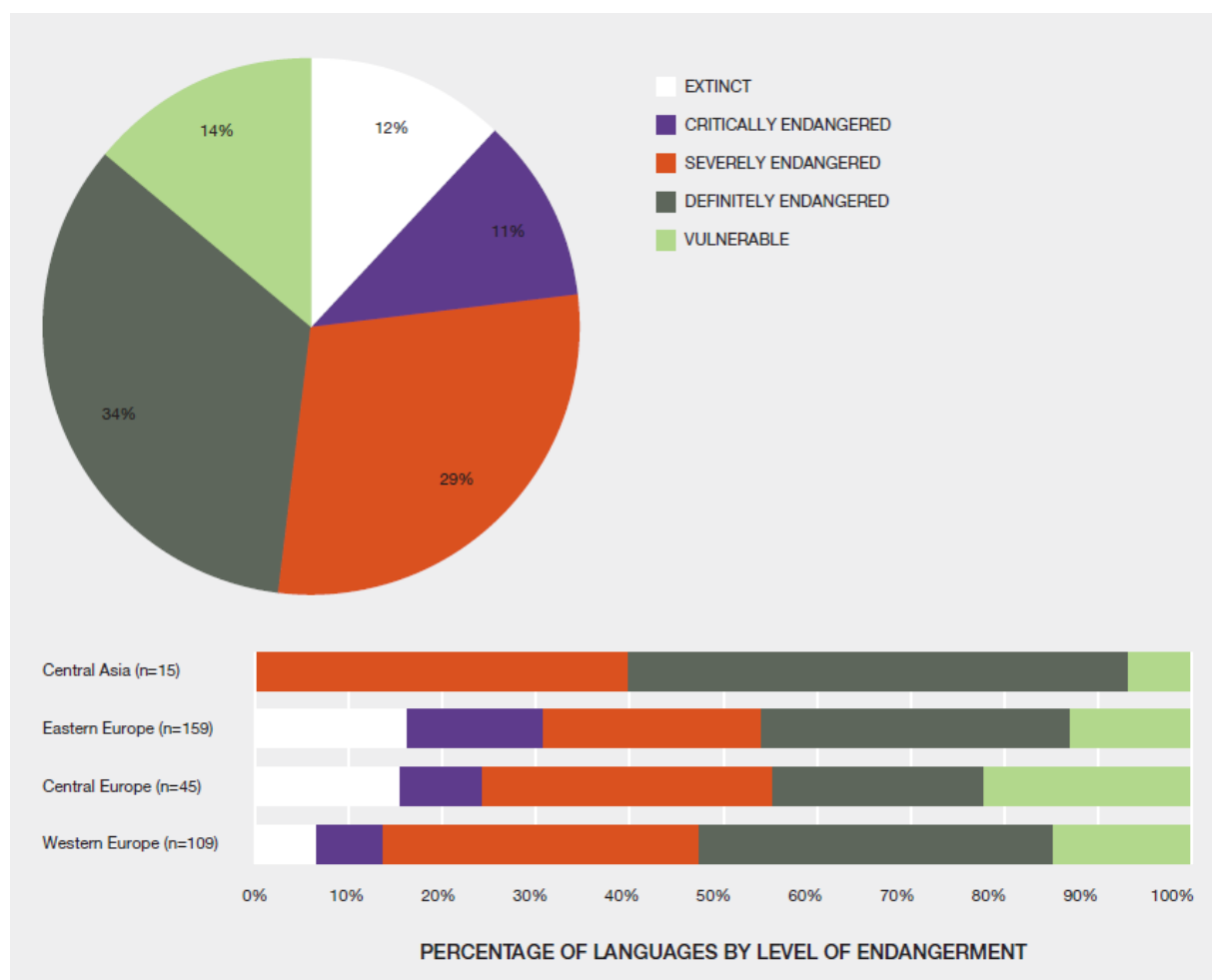


Figure 2.38: Level of endangerment of languages in Europe and Central Asia (left) and level of endangerment by subregion (right). (Own representation based on: Moseley (2010); UNESCO (n.d.). Overseas territories in other regions are not included.

²⁰ Extinct: There are not speakers

²¹ Critically endangered: The youngest speakers are grandparents and older, and they speak the language partially and infrequently

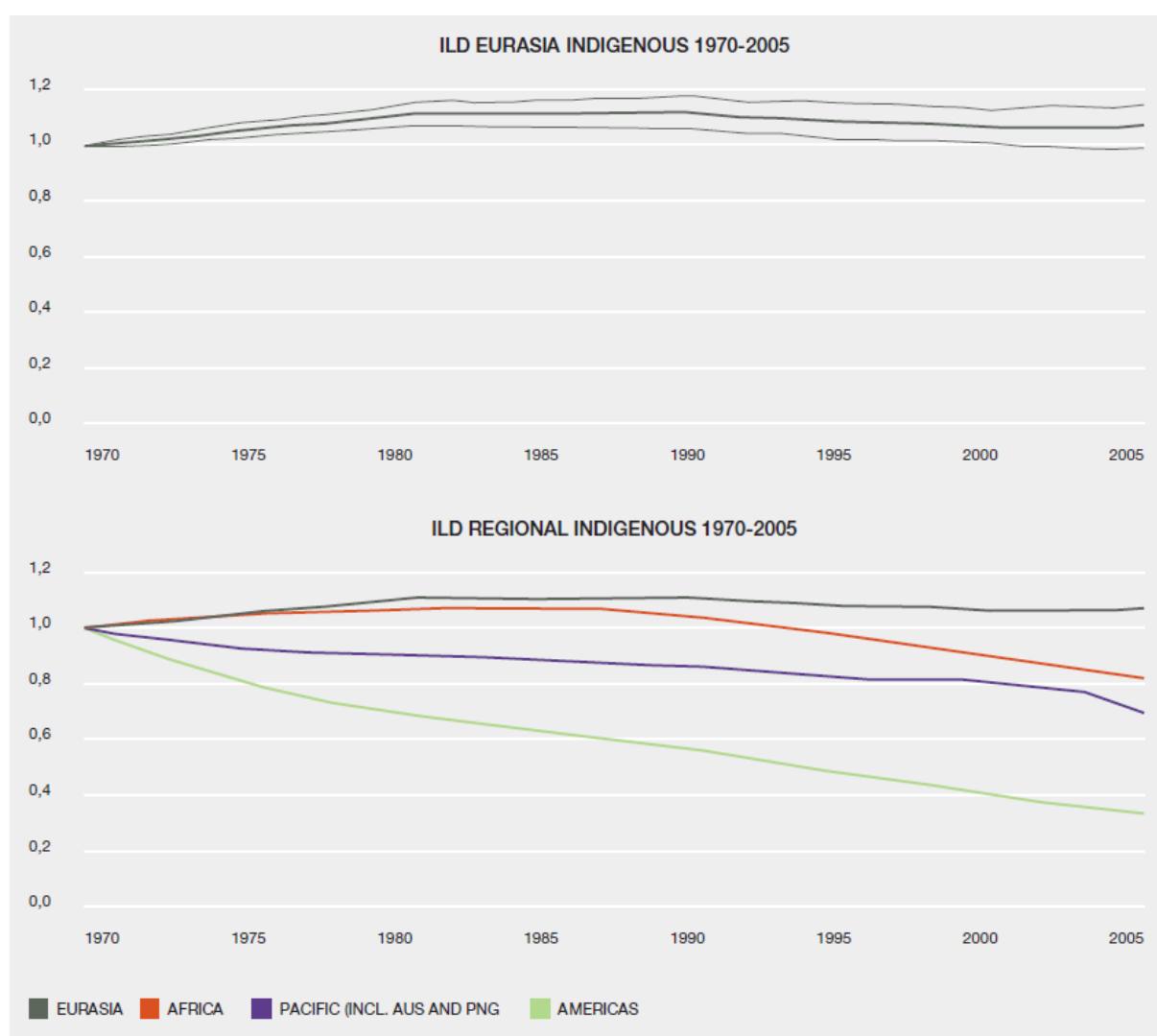


Figure 2.39: Trends of the Index of Linguistic Diversity in Eurasia (ILD) (top) and in the different regions (bottom). Source: Harmon & Loh (2010).

The general loss of indigenous and local knowledge is mainly attributed to the transition from an agriculturally-based and subsistence-oriented economy to a market-oriented economy (Carvalho & Morales, 2010; Hernández-Morcillo et al., 2014; Pardo-de-Santayana et al., 2010). Changes in culture that affect shared beliefs, meanings and practices regarding plants and animals or other contributions from nature to people, are also responsible for the lack of value associated with indigenous and local knowledge among younger generations, which consider these traditional practices and knowledge as symbols of poverty or backwardness (Christanell et al., 2010; Hernández-Morcillo et al., 2014; Pardo-de-Santayana et al., 2010). Gender relations are of special interest in Western Europe, where women and men have had differentiated roles in preserving indigenous and local knowledge (Pardo-de-Santayana et al., 2010; Reyes-García et al., 2010). Demographic changes, such as ageing of indigenous and local knowledge holders, rural abandonment and outmigration of women and younger generations from rural areas, have also led to a marked decline in generational transmission of indigenous and local knowledge (Fernández-Giménez & Fillat Estaque, 2012; Molnár, 2014; Oteros-Rozas et al., 2013b). These factors are also acknowledged by indigenous and local knowledge holders as powerful drivers of erosion of their knowledge (see also electronic Appendix 2.2).

Some governmental policies can also support the maintenance of indigenous and local knowledge. For example, the Common Agricultural Policy reform legislation offers support for “high nature value” farming, which is characterized by long-established, low-intensity and holistic farming systems highly adapted to local environmental conditions (Keenleyside et al., 2014). In this sense, high natural value farming is not only essential if the European Union is to meet its 2020 biodiversity targets, but also to counteract the decline in indigenous and local knowledge.

There is a proven gap in documentation of indigenous and local knowledge in Central Asia and therefore more studies are needed on how traditional practices and indigenous and local knowledge associated with nature could bring important insights into biocultural diversity conservation in the subregion (Pawera et al., 2016). In addition, although there is some evidence about the role of indigenous and local knowledge in marine systems (Maynou et al., 2011; Moore, 2003), more research is needed to report on the status and trends of this knowledge in that context.

2.2.3.2 *Physical and psychological experiences*

2.2.3.2.1 *Recreational experiences*

Nature in Europe and Central Asia provides opportunities for recreation such as hiking, trekking, climbing, running, mountain biking, horseback riding, camping, picnicking, sailing, boating, swimming, snorkeling or diving, skiing and green care, as well as activities related to species, such as wildlife-watching, particularly birdwatching. Nature also provides opportunities to perform extractive recreational activities, such as hunting, fishing and angling, mushroom gathering, berry and fruit picking (Bell et al., 2007; Schulp et al., 2014a; Seeland & Staniszewski, 2007). Thirty-eight per cent of the European Union is characterized by high outdoor recreation potential (Paracchini et al., 2014), particularly coastal and freshwater systems and broadleaved woodlands (Hornigold et al., 2016). Recreation is a well-recognized contribution from nature to people in broadleaved forests of Western and Central Europe (e.g. (Grilli et al., 2015; Mavsar et al., 2013; Sténs et al., 2016)). In freshwater ecosystems, recreation is more common in rivers with clear water and high flows than rivers with mud, algae and litter (Eder & Arnberger, 2016; Vesterinen et al., 2010). Marine and coastal systems also provide the basis for recreational activities, such as recreational fishing, birdwatching, whale-watching, swimming, diving and snorkeling or other water sports (Ahtiainen et al., 2013; Beaumont et al., 2007). In the last decades, the capacity for nature-based recreation in the aforementioned ecosystems has decreased because of land-use change (e.g. Lique et al. (2016); Pietilä & Fagerholm, (2016); Roberge et al. (2016)).

Green spaces in urban areas provide multiple physical and psychological experiences (Bolund & Hunhammar, 1999; Kabisch et al., 2016), such as sense of peacefulness and tranquility (Chiesura, 2004) or hiking and walking (Baró et al., 2016; Smrekar et al., 2016). While an overall increase in urban green spaces was identified in Western Europe from 2000 to 2006, most of the cities of Central and Eastern Europe experienced a decline in the same period (Kabisch & Haase, 2013). The recreational experience in urban green spaces depends on different elements, such as the presence of forests and wetlands or riparian systems (Baró et al., 2016) or high species richness (Fuller et al., 2007). Urban gardens are increasingly recognized among these elements in Western and Central Europe (Simon Bell, 2016; Breuste & Artmann, 2015; Camps-Calvet et al., 2015).

Nature-based recreation is in high demand in Europe and Central Asia (e.g. Agbenyega et al. (2009); García-Llorente et al. (2012); Sténs et al. (2016)). For example, 31% of people surveyed in the European Union gave nature as their main reason for going on holiday. Other reasons were nature related, such

as beach and sport-related activities (e.g. cycling, boating or diving), which were mentioned by 51% of people surveyed in the European Union (European Commission, 2016b). In the last decade, nature as the main reason for holidays has increased in the European Union (**Figure 2.40**). Participation in nature-based recreation is not equally distributed between countries due to differences in the number of protected areas (**Table 2.5**), forest areas designated for recreational purposes (**Figure 2.41**), or accessibility to natural areas (Bell et al., 2007).

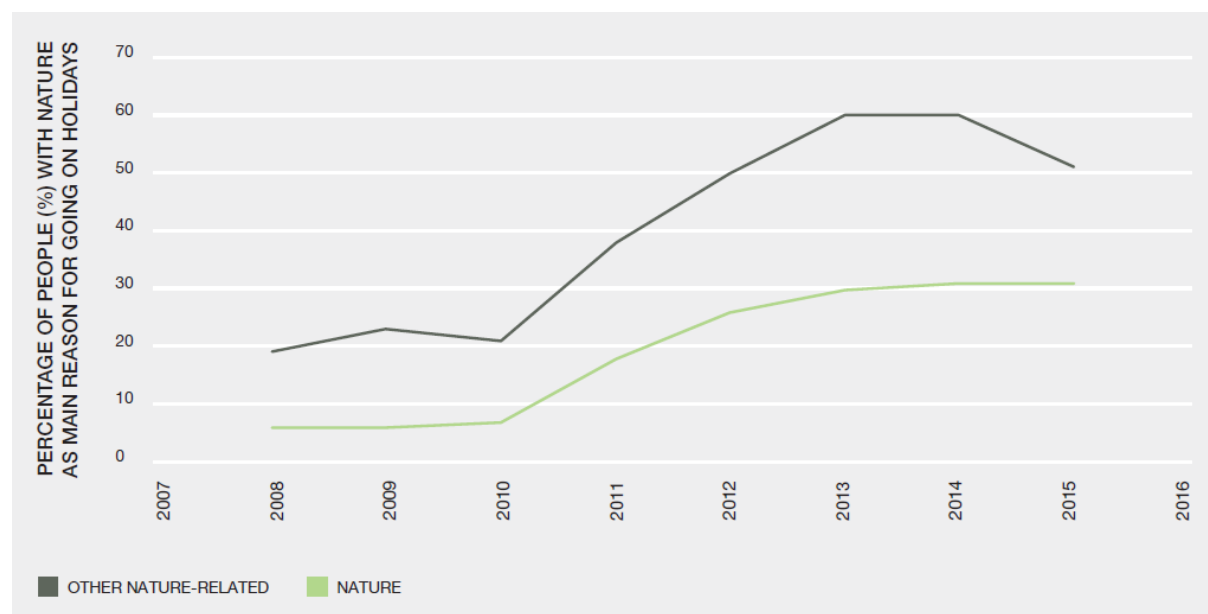


Figure 2.40: Demand for nature-based recreation in the European Union. Trends of percentage of people in the European Union with nature (i.e. ecosystems or landscapes) and other related-nature (beach and sport-related activities, e.g. scuba-diving, cycling, etc.) motivations as the main reasons for going on holiday. Own representation based on Eurobarometer.

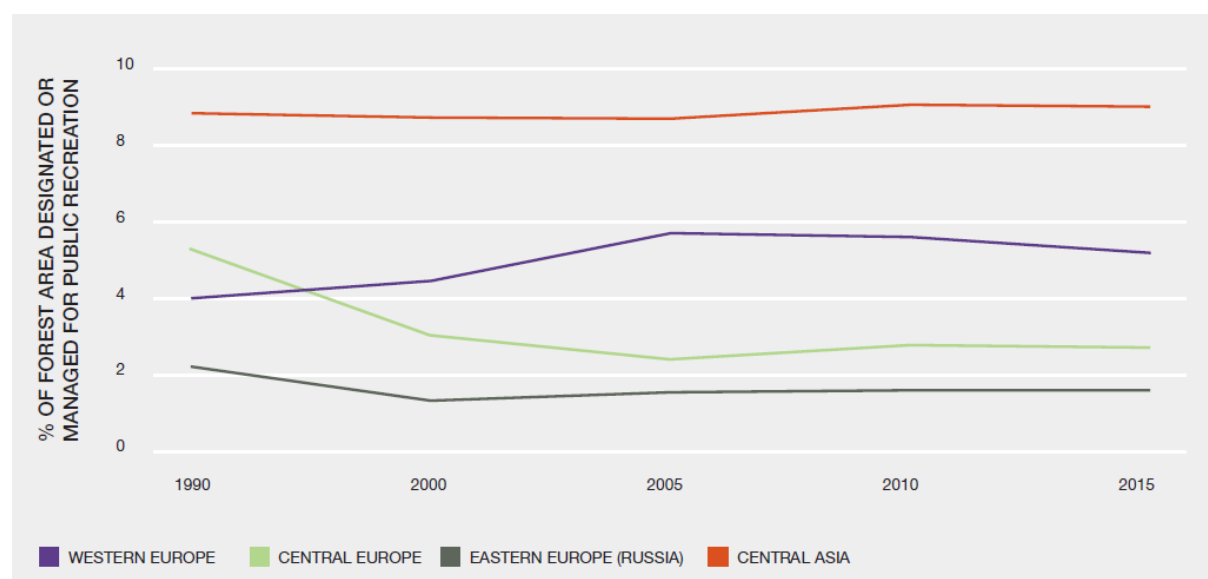


Figure 2.41: Distribution of recreational options in Europe and Central Asia: Temporal trends of the forest surface managed or designated for recreational purposes in the four subregions. Own representation based on <http://www.fao.org/forest-resources-assessment/en/>

Nature's capacity to provide extractive outdoor experiences relies on a variety of species. In the European Union, 97 species are hunted, while 152 species and 12 genera of mushrooms and 592 edible plant species are reported as being collected (Schulp, Thuiller, et al., 2014). However, this estimation is incomplete because studies in Turkey showed that at least 2,000 species of mushrooms are edible (Çağlarırmak, 2011; Kizmaz, 2003). The highest richness of game species is reported in Central Europe, southern Scandinavia and the Baltic countries, while for edible mushroom and plant species it is the forested and mountainous areas of Western Europe (Figure 2.42) (Schulp et al., 2014a).

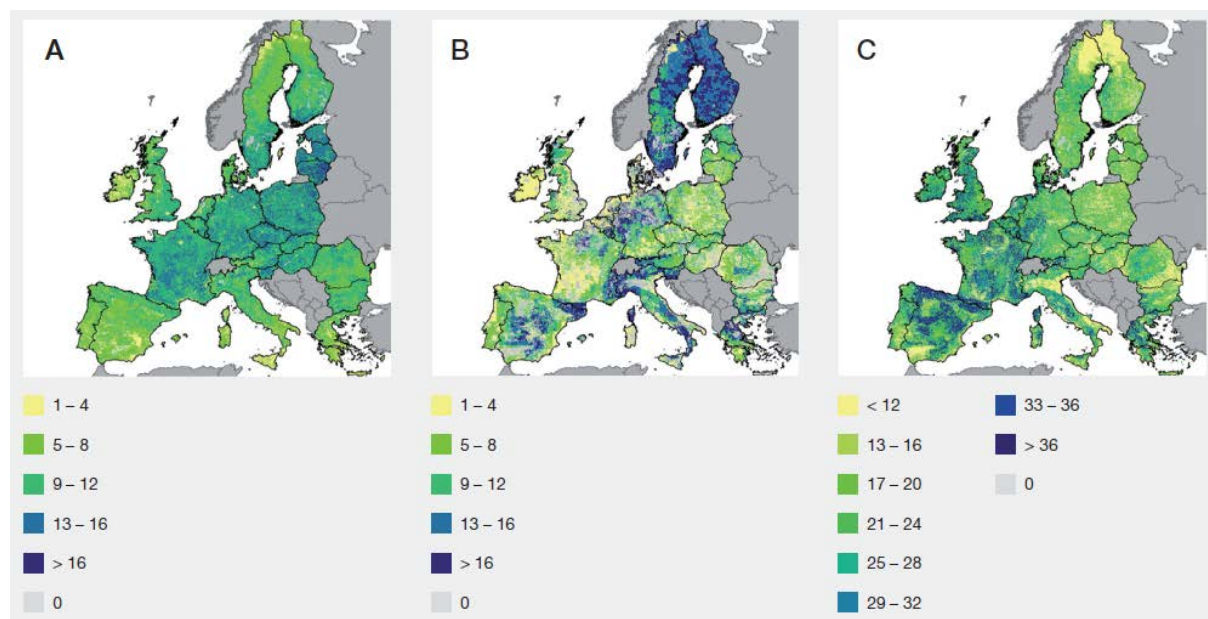


Figure 2.42: Species richness of the 38 common game species in the European Union (A), 27 common edible mushroom species in the European Union (B), and 81 common wild food vascular plant species in the European Union (C). Source: Schulp et al. (2014b)

Hunters as a percentage of the European Union population in 2010 varied between 0.17% (Netherlands) and 12.4% (Italy) (Schulp et al., 2014a). In Central Asia, the flourishing of sport hunting (Kronenberg, 2014) and the presence of body parts of particular animals (e.g. snow leopard (*Uncia uncia*), Asiatic Bear (*Ursus arctos isabellinus*)) in markets suggest both legal and illegal hunting (Cunha, 1997; Haslinger et al., 2007). Recreational fishing is a growing phenomenon in Western Europe (Toivonen et al., 2004). Collection of mushrooms, truffles, berries, fruits and edible nuts is more prevalent in Western Europe than Central Europe and Eastern Europe (Figure 2.43) (Mcpfe et al., 2007). However, the diversity of wild plants collected has suffered a decline in recent decades in Western and Central Europe (Łuczaj et al., 2012; Reyes-García et al., 2015; Rządowski & Kalinowski, 2013). This decline coincides with urbanization and loss of natural habitats, rural abandonment, cultural change, the erosion of indigenous and local knowledge, and industrialization of food production (Łuczaj et al., 2012; Reyes-García et al., 2015). By contrast, some uses of wild edible plants are preserved due to a revival of traditions linked with “traditional” cuisine (Reyes-García et al., 2015; Schulp, et al., 2014b).

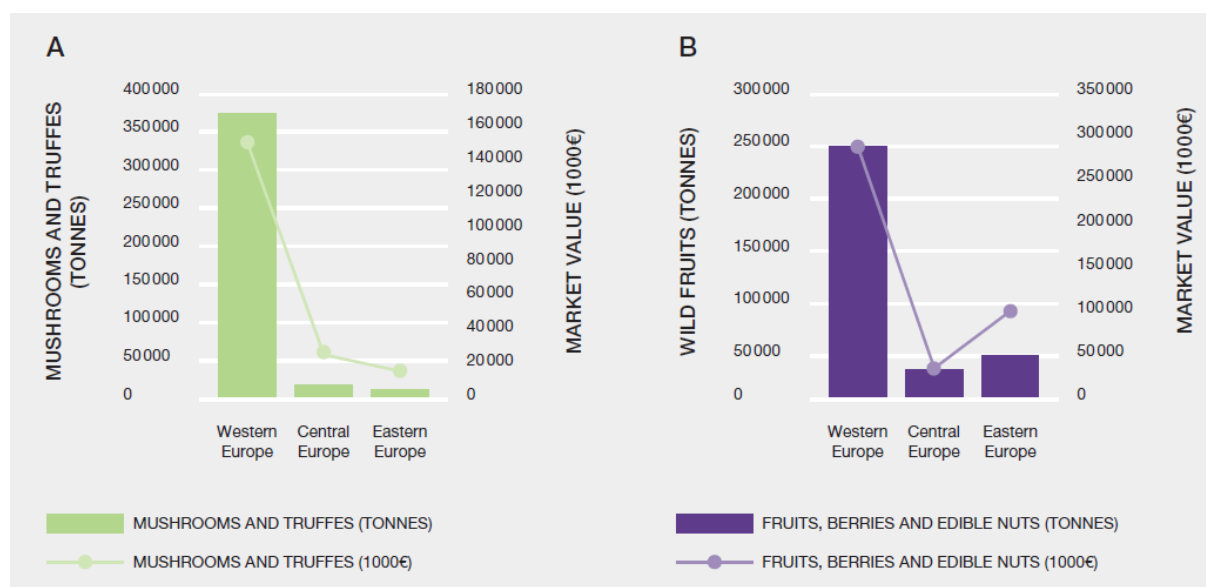


Figure 2.43: Distribution of the amount and market value of (A) mushroom and (B) berries, fruits and edible nuts picked in forests in Western, Central and Eastern Europe. Own representation based on Mcpfe et al. (2007).

2.2.3.2.2 Aesthetic experiences

Nature is a source of aesthetic experiences for people in Europe and Central Asia (e.g. Daniel (2001); Kaplan & Kaplan (1989); Ode et al. (2009); Schirpke et al. (2013)). Aesthetic enjoyment is dependent on perceived naturalness (e.g. Arriaza (2004); Van den Berg & Koole (2006)), landscape heterogeneity (e.g. Dramstad et al. (2006); Frank et al. (2013); Schirpke et al. (2013); Sevenant & Antrop (2009)), and high levels of biodiversity (e.g. Casalegno et al. (2013); Lindemann-Matthies et al. (2010); Tribot et al. (2016)).

People in Western and Central Europe prefer natural areas with verdant vegetation over arid landscapes and urban landscapes (García-Llorente et al., 2012; Sevenant & Antrop, 2009). Landscape configurations like open forests (Gundersen & Frivold, 2008; Hansen & Malmaeus, 2016) or wood-pastures are most preferred among verdant natural areas (e.g. Plieninger et al. (2015); Surová et al. (2013); Van Zanten et al. (2014)). However, mosaic landscapes were considered to have higher aesthetic value than landscapes dominated by forest in Western and Central Europe (e.g. García-Llorente et al. (2012); Howley (2011); Howley et al. (2012); Schirpke et al. (2013))). Mountains and coastal systems also provide aesthetic enjoyment, expressed by high numbers of related geotagged photographs (Oteros-Rozas et al. (2017); Van Zanten et al. (2016)). Water features also contribute to aesthetic pleasure (e.g. (Kaltenborn & Bjerke, 2002; Tveit et al., 2006; Van Zanten et al., 2016)).

The capacity of landscapes to provide aesthetic experience has declined because of urbanization, land-use intensification, rural abandonment, disappearance of common lands and water pollution (see Chapter 4) (Šmid Hribar et al., 2015; Hunziker et al., 2008; Ruskule et al., 2013).

2.2.3.3 Supporting identities

Individuals derive a good quality of life from knowing of the mere existence of particular species, ecosystems or a landscapes, independent of their actual use (Krutilla, 1967; Reyers et al., 2012), but

also from their sense of place, cultural heritage, and from spiritual experiences. In contrast to physical and experiential values (see Section 2.2.3.2), this contribution from nature to people relates to virtues and principles (Chan et al., 2012).

2.2.3.3.1 Protected areas

Protected areas indicate where societies have expressed their will to protect species and ecosystems. Protected areas can take many forms, as distinguished by (IUCN, 2017). Some categories of protected areas contain core zones, where natural dynamics can take place and which are largely inaccessible to the public. These categories are: “Ia Strict Nature Reserve”, “Ib Wilderness Area”, “II National Park” and “IV Habitat/species management area”. The status of these protected areas in Europe and Central Asia, as reported in the World Database on Protected Areas (UNEP-WCMC & IUCN, 2016), was used as an indicator for “supporting identities” (see **Figure 2.44** and **Table 2.5**). Globally, there has been an increase in protected areas (all IUCN categories) from about 8% in 1990 to 14.7% in 2016 (UNEP-WCMC & IUCN, 2016). It should be noted that motivations to establish a protected area differ, so the chosen indicator does not necessarily reflect particularly important species and ecosystems (Joppa & Pfaff, 2009).

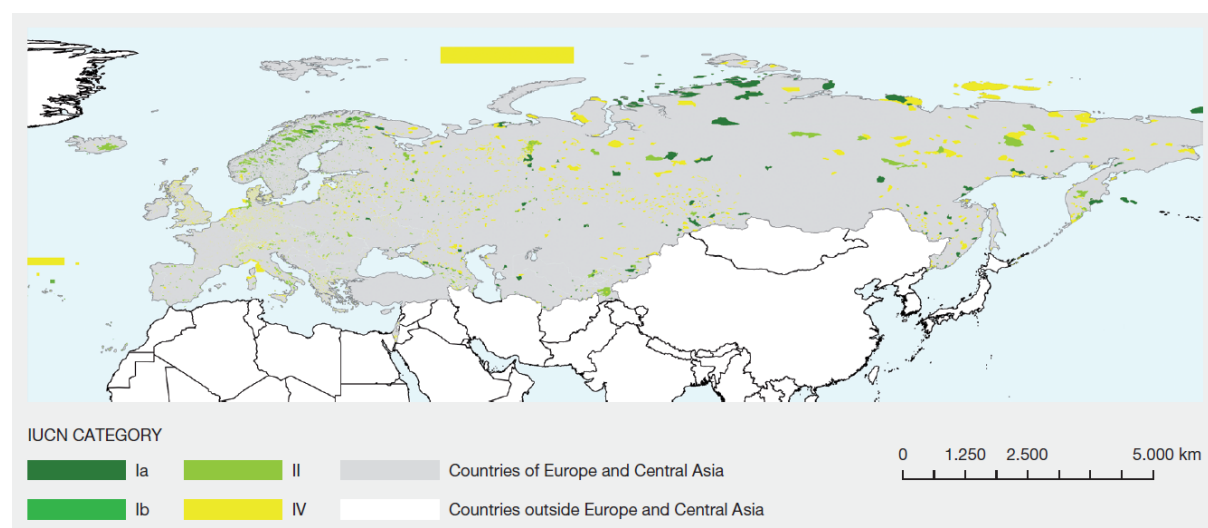


Figure 2.44: Terrestrial and marine protected areas in Europe and Central Asia. The map displays strong protection categories (Ia, Ib, II and IV). Source: World Database on Protected Areas (WDPA, UNEP-WCMC & IUCN 2016: <https://www.protectedplanet.net/>).

Table 2.5: Proportion of protected areas in Europe and Central Asia. The table displays strong protection categories (Ia, Ib, II and IV) in the four subregions. Source: World Database on Protected Areas (WDPA, UNEP-WCMC & IUCN 2016: <https://www.protectedplanet.net/>).

Region	Ia Strict nature reserve [% of land area]	Ib Wilderness area [% of land area]	II National Park [% of area]	IV Habitat/species management area [% of land area]	Total area (in km ²) of categories Ia, Ib, II and IV
Central Europe	0.00	0.27	0.87	0.93	92,284

Western Europe	0.48	2.70	3.16	1.60	1,077,634
Eastern Europe	1.91	0.00	1.02	5.20	6,930,197
Central Asia	0.68	0.00	0.65	1.04	196,475

4325

4326 2.2.3.3.2 Emblematic, symbolic or iconic species or ecosystems

4327 An existence value can be attributed to emblematic, symbolic or iconic species or ecosystems that are
4328 particularly appreciated for their existence, independent of their actual use for recreation (e.g., bird
4329 watching, game viewing). Certain so-called “flagship species” have drawn wide public interest (Barua,
4330 2011). Many of these species’ habitats occur outside Europe and Central Asia, for example the tiger
4331 (*Panthera tigris*), gorilla (*Gorilla gorilla*), giant panda (*Ailuropoda melanoleuca*), orangutan (*Pongo*
4332 *abelii*), as well as elephants and seahorses (Barua, 2011). The contribution from nature to people in
4333 these cases is not provided by ecosystems in Europe and Central Asia, but is valued by people within
4334 the region. There is currently a knowledge gap on how iconic and emblematic species that *are* native
4335 to Europe and Central Asia are perceived across the region. The wolf (*Canis lupus*), brown bear (*Ursus*
4336 *arctos*), wolverine (*Gulo gulo*), lynx (*Lynx lynx*) and wisent (*Bison bonasus*) have been framed as
4337 “Europe’s big five” in collaboration with conservation experts (IUCN, 2014). A global meta-analysis
4338 found that species in forest and marine inland waters are particularly highly valued. Of these species,
4339 the moose (*Alces alces*) and the humpback whale (*Megaptera novaeangliae*) (Martín-López et al.,
4340 2008) occur in Europe and Central Asia. Furthermore, there is country-specific evidence of people
4341 assigning particular existence values to species. For instance, people in Sweden value large carnivores,
4342 irrespective of having the possibility to view them (Karlsson & Sjöström, 2008). In Spain, the imperial
4343 eagle (*Aquila adalberti*) and the Iberian lynx (*Lynx pardinus*) were among the species for which people
4344 showed the highest preference and willingness-to-pay for their conservation (Martín-López et al.,
4345 2007b). In the UK, White et al. (2001) found high conservation interest for the otter (*Lutra lutra*),
4346 measured through high willingness-to-pay for their conservation. Preferences for the existence of
4347 species, such as willingness-to-pay for marine biodiversity, can differ across the region (Ressurreição
4348 et al., 2012). Willingness-to-pay for conservation has also been shown to be more strongly influenced
4349 by certain marine iconic species that are actively experienced (seals, octopus, birds) than by species
4350 that do not directly have a use value (i.e. are only protected for their existence) (Jobstvogt, 2014).

4351

4352 2.2.3.3.3 Attitudes towards nature

4353 Another indication of this contribution from nature to people is attitudes towards nature
4354 conservation. In the EU-28, 76% of the people totally agree with the statement “We have a
4355 responsibility to look after nature”. This percentage differs regionally, ranging from 65% in Italy to 94%
4356 in Cyprus and Sweden (European Commission, 2015a). See also electronic Appendix 2.2 with quotes
4357 recognizing a decreasing trend of appreciation of nature by young holders of indigenous and local
4358 knowledge.

4359

4360 2.2.3.3.4 Spiritual experiences

4361 Ecosystems have traditionally served as areas for spiritual or religious rituals and experiences derived
4362 from nature (Groot et al., 2005). Natural areas of special spiritual significance include areas recognized
4363 as sacred by indigenous and traditional peoples as well as by institutionalized religions or faiths as
4364 places for worship and remembrance (Verschuuren et al., 2010). Sacred or holy natural places occur

at a variety of scales in Europe and Central Asia, varying from rock formations or forest patches to mountains and islands. Electronic Appendix 2.6 shows a selected list of natural areas considered as “sacred natural sites” based on IUCN’s Task Force on Cultural and Spiritual Values of Protected Areas (Wild & McLeod, 2008) and the Delos Initiative (Mallarch & Papayannis, 2012). Five sites on this list are located in Central Europe, three in Eastern Europe, 17 in Western Europe and one in Central Asia. The importance of these sites and other natural areas of spiritual and cultural significance to the quality of life in Europe and Central Asia is elaborated on in Section 2.3.3.

2.2.3.4 Maintenance of options

The desire to maintain potential options or benefits provided by nature for future generations is an expression of how people value inter-generational justice (see Section 2.3.4). The capacity of supply of this contribution from nature to people is indicated by overall patterns in species-level biodiversity (see **Table 2.6**, Section 3.2.3). One measure of the unique contribution to this contribution is given by total number of endemic species, which is low for Europe and Central Asia relatively to Africa, Asia and Pacific and America regions (see **Table 2.6**). Phylogenetic diversity (Faith, 1992) over multiple taxonomic groups is also an informative metric of the capacity of biodiversity to deliver maintenance of options (Faith, 2016) (also see Chapter 3). An assessment of the phylogenetic diversity of birds and mammals (see **Figure 2.45**) (Pollock et al., 2017) identified many high priority areas, such as in southern Croatia, the Odessa region of Ukraine, and north-western Kazakhstan, for their better conservation.

Table 2.6: Numbers of classified, endemic and threatened species as proxy for the status of the maintenance of options of nature’s contributions to people in Europe and Central Asia relative to the other three IPBES regions (the Americas, Asia and the Pacific, and Africa). Source: Brooks et al. (2016), data for taxonomic groups that have been comprehensively assessed using IUCN red list criteria. Total global # of assessed species, over all these assessed groups, = 32,790. Total # of these assessed species that are threatened = 6,539.

	Europe and Central Asia	Average value over the other 3 IPBES regions
Number of assessed species, over all assessed groups, that are found in nominated IPBES region	2487	11840
Number of those species endemic to the region	332	9681
Number of assessed species that are threatened and are found in nominated region	302	2251
Number of those threatened species that are endemic to the region	83	2036

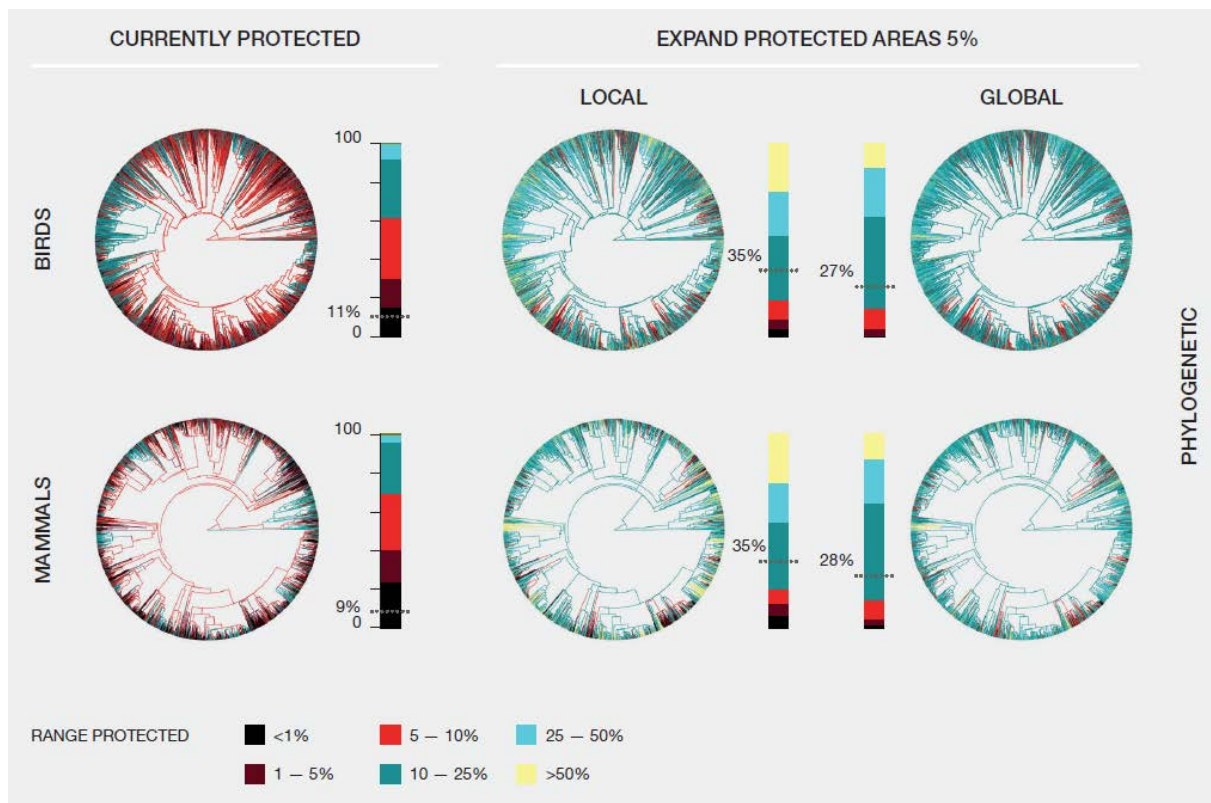


Figure 2.45: Status of protection of phylogenetic diversity shown on the phylogenetic trees for birds and mammals. Tree diagrams on the left show current protection levels, and tree diagrams on the right use colours to show potential conservation gains for a 5 per cent increase in protected areas. For each branch of each tree, degree of protection is defined as the percentage of the total branch occurrences that is protected (percentage of “range protected”). Source: Pollock et al. (2017)

The maintenance of options from biodiversity in Europe and Central Asia (and from outside the region) can be assessed through the valuation of genetic diversity by pharmaceutical companies (see Section 2.2.2.4). After a period of reduced interest there is a shift back towards natural products, supported by improved methods to explore species’ DNA to search for useful compounds (Piper, 2017). The appreciation for this contribution from nature to people is also found in the greater awareness of recent unanticipated benefits from biodiversity. The State of the World’s Plants (Willis, 2017) provides examples of benefits from genetic variation. For example, the ash tree (*Fraxinus excelsior*) is suffering dieback across northern parts of Western Europe from a fungus; however, whole genome sequencing has helped characterize the genetic diversity, so that resistant individuals can be identified.

Medicines derived from medicinal plants (see Section 2.2.2.4) and from marine organisms also raise awareness of biodiversity option values. However, benefits of this contribution from nature to people also may include other products. For example, it has been found that honeycomb moth caterpillars can eat through plastic (Bombelli et al., 2017). The caterpillars are beewax-eating pests, but enzymes from the caterpillars provide an un-expected global benefit. Another example is the recent published role of golden jackals (*C. aureus*), long regarded as a pest, as a remover of domestic animal carcasses, which is saving about two million euros in those countries west of Black Sea with estimated jackal population size >100 individuals –i.e. Bosnia and Herzegovina, Bulgaria, Croatia, Greece, Hungary, Romania and Serbia- (Ćirović et al., 2016). The appreciation and value of this contribution from nature to people can also be estimated through the ongoing reporting of surprising discoveries in the popular press. For example, the golden jackals’ example was widely communicated through a New Scientist

article²². Such examples can reinforce people's relational value, linking biodiversity to future generations' quality of life (Faith, 2016). The Millennium Ecosystem Assessment (2005) concluded that *"the value individuals place on keeping biodiversity for future generations—the option value—can be significant"*. Recently, a consortium of IUCN and global conservation NGOs argued for the value of biodiversity in maintaining options, providing many examples of past surprising benefits from biodiversity (Gascon et al., 2015).

2.2.4 Interregional flows of nature's contributions to people: dependency of Europe and Central Asia on ecosystems of other regions

2.2.4.1 Introduction: interregional flows of nature's contributions to people

Nature's contributions to people being used in Europe and Central Asia are provided by ecosystems both within and outside the region. Through interregional flows of nature's contributions to people, i.e. the active or passive transport of energy, matter or information, differences between the provision and actual consumption of ecosystem services can be balanced (Liu et al., 2016). Flows of nature's contributions to people happen both between subregions of Europe and Central Asia, and between the region and other parts of the world. Interregional flows of nature's contributions to people involve telecoupling, i.e. socioeconomic and environmental interactions over distances (Liu et al., 2016), and have several consequences. Ecosystem service use in one location can have impacts on ecosystems in other locations, such as degradation and connected loss of biodiversity (Mayer et al., 2005). For example, deforestation embodied in final consumption of the EU-27 equated to 732,000 ha (2004). In other words, 10% of the world's annual deforestation (7,290,000 ha per year) was the result of consumption by the EU-27 (see **Figure 2.46**) (European Commission, 2013b).

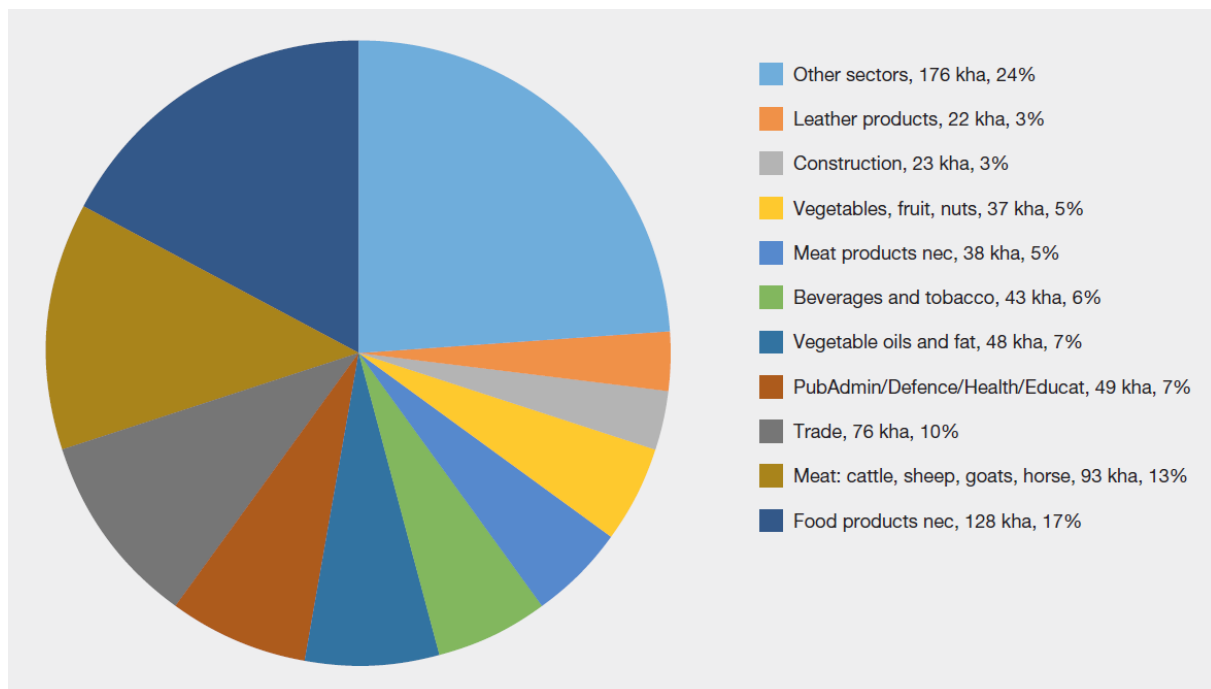


Figure 2.46: Consumption of nature's contributions to people associated with global deforestation allocated by sector for the EU-27 (2004). Brazil, Argentina, Paraguay, Indonesia and Malaysia,

²² (<https://www.newscientist.com/article/2090451-invasive-trash-eating-jackals-save-europe-e2-million-a-year/>)

among others, have been identified as important sources of embodied deforestation. Source: European Commission (2013b)

Furthermore, interregional flows can have effects on quality of life, such as distributional equity, as discussed in the context of land grabbing (see Section 2.3.1.1) (Rulli et al., 2013). On the other hand, interregional flows of nature's material contributions to people can lead to overall lower costs of food (Schmitz et al., 2012). Additionally, access to goods from outside the region through trade contributes to food security (see Section 2.3.1.1) as well as supporting livelihoods in the producing country.

2.2.4.2 Ecological footprint

Ecological footprint is a composite indicator for use of nature's contributions to people (Borucke et al., 2013; Kitzes & Wackernagel, 2009) that quantifies the area needed to provide certain material or regulating contributions and expresses consumption in an area in terms of the area needed to renewably provide those contributions (Kitzes & Wackernagel, 2009). Ecological footprint includes proxies for nature's contributions to people such as crops, grazing land, fish, timber, and carbon sequestration (Borucke et al., 2013). Biocapacity is another proxy for ecosystem productivity. Data on the ecological footprint of consumption and on biocapacity (in global hectares per person) are available for most of the countries within Europe and Central Asia (missing: Andorra, Iceland, Liechtenstein, Monaco, San Marino). For Europe and Central Asia in 2013, the ecological footprint (consumption) was 4.6 ha and biocapacity only 2.9 ha (based on 49 countries) (Global Footprint Network, 2017). This indicates that the region either overuses or net imports renewable natural resources. Both ecological footprint and biocapacity differ regionally, and so does the difference between the two measures (Figure 2.47). For Western Europe (data for 19 of 24 countries), the footprint was 5.1 ha, vs. 2.2 ha biocapacity; for Central Europe (all 18 countries) the footprint was 3.6 ha, vs. 2.1 ha biocapacity, for Eastern Europe (all seven countries) the footprint was 4.8 ha, vs. 5.3 ha biocapacity; and for Central Asia (all five countries) the footprint was 3.4 ha, vs. 1.7 ha biocapacity. This means that Western and Central Europe and Central Asia have a deficit, while Eastern Europe has a reserve, in terms of biocapacity. A deficit can be ascribed to overuse of local renewable resources or net import (interregional flows) of renewable resources for consumption. In Figure 2.47 countries shaded green have high biocapacity, so they have a reserve despite some also having large ecological footprints.

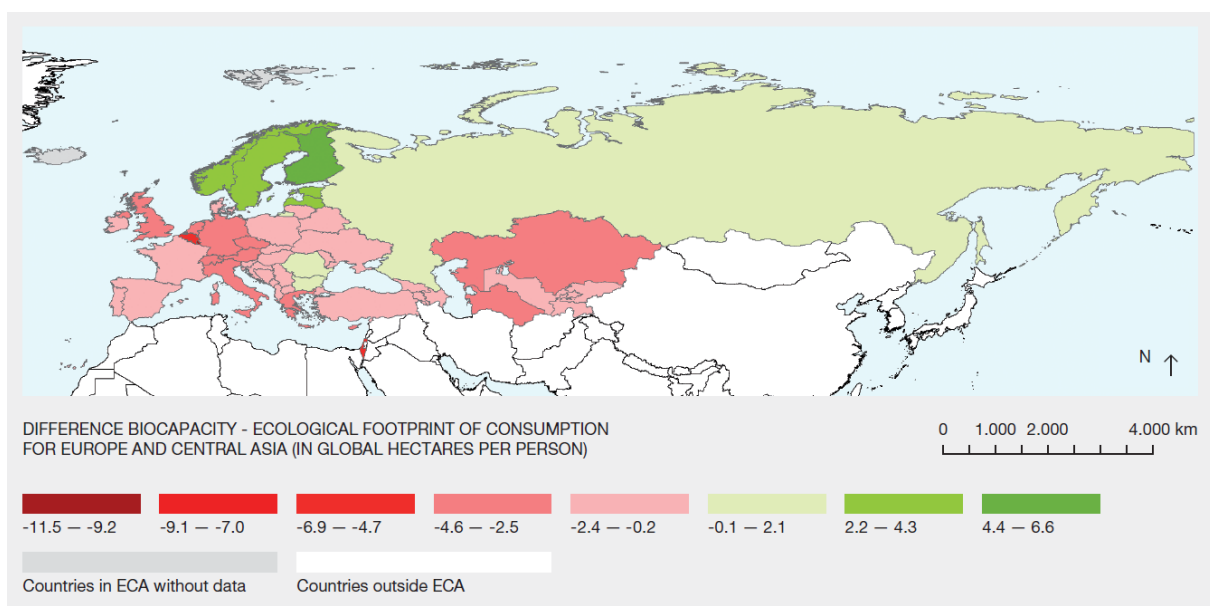


Figure 2.47: Difference between biocapacity and ecological footprint (consumption) in global hectares per person for Europe and Central Asia (ECA). Own representation based on (Global Footprint Network, 2017)).

2.2.4.3 Status and trends of interregional flows for selected nature's contributions to people

Human appropriation of net primary productivity (HANPP) is a measure that includes biomass extraction from ecosystems for food, fodder, fibres and bioenergy. For large parts of Western Europe, HANPP appropriated is lower than HANPP embodied in consumption. For Central and Eastern Europe and Central Asia, HANPP of the region is about the same as or slightly higher than HANPP embodied in consumption (Erb et al., 2009a, 2009b). European Union imports embodied HANPP to an increasing extent, in particular from South America (Kastner et al., 2015) (see **Figure 2.48**).

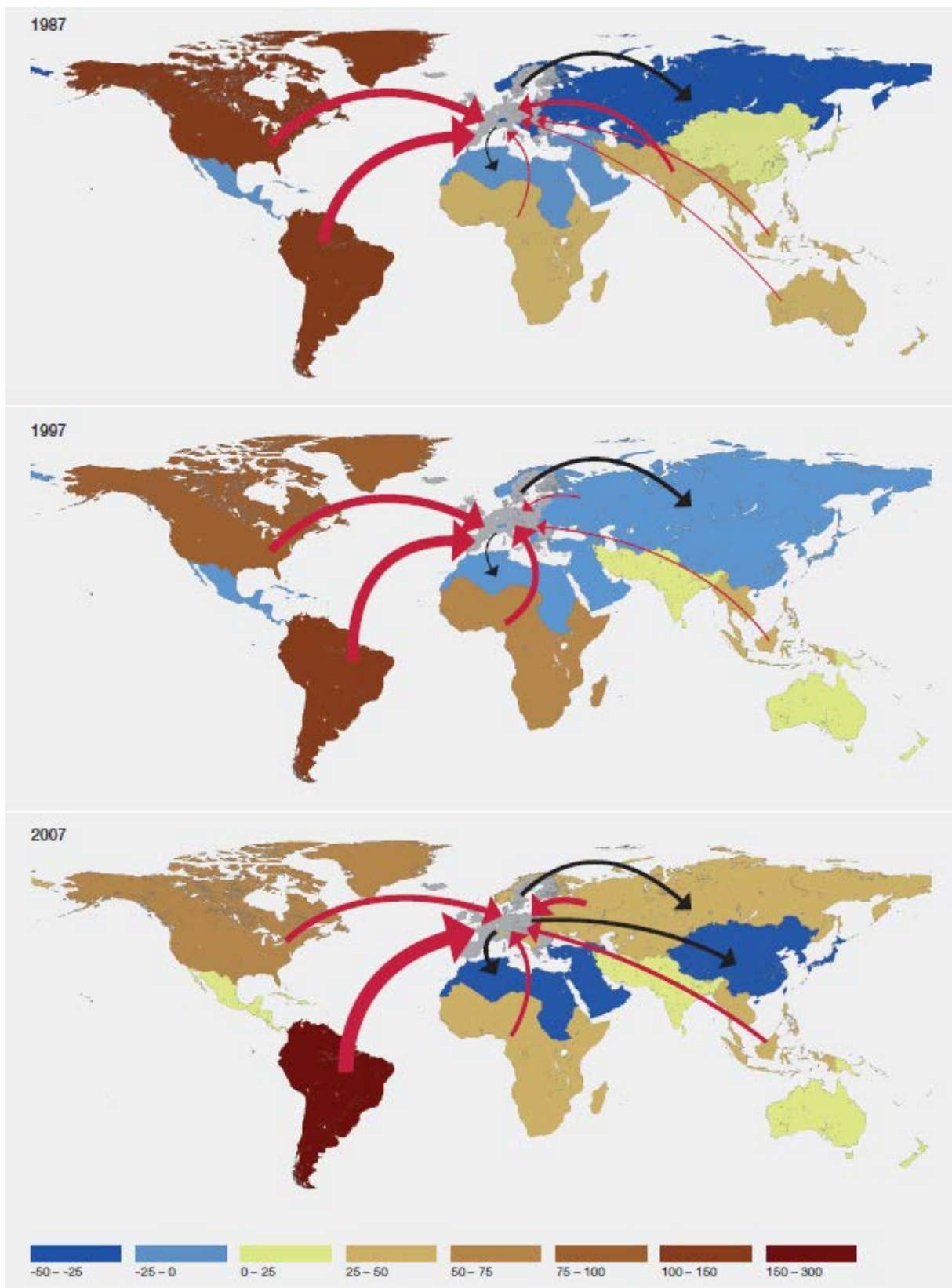


Figure 2.48: Human appropriation of net primary productivity (HANPP) (Mt dm/yr) embodied in trade between the European Union and ten world regions. Arrows indicate the largest flows (red=import, black=export) (from (Kastner et al., 2015).

Central and Western Europe depend on land elsewhere for crop production to a large degree; Eastern Europe and Central Asia to a lesser degree. Main sources are Brazil, Argentina, China and the USA (Yu et al., 2013). In 2008 Western Europe showed relatively low levels of self-sufficiency in terms of crop production and consumption, while Central and Eastern Europe as well as Central Asia showed higher production than consumption levels (i.e. self-sufficiency ratio larger than 1) (see **Figure 2.49**) (Kastner et al., 2014). See Section 2.3.1.1 on food security.

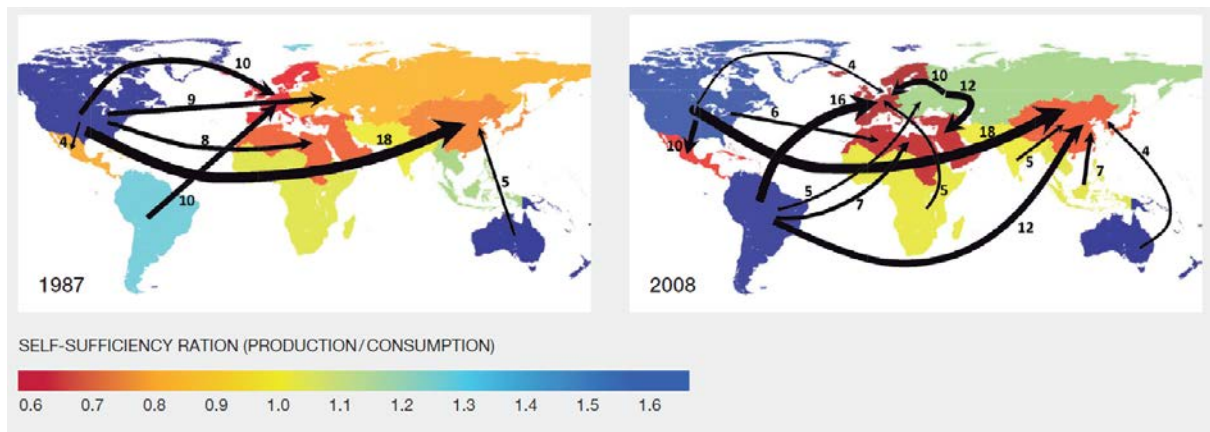


Figure 2.49: Croplands (million ha harvested per year) related to import and export of crops. Source: Kastner et al. (2014).

Worldwide median minimum distance from fishing source to place of consumption has increased from about 500 km in 1950 to about 2,500 km in 2011 (Watson et al., 2015). Seafood exports from Europe and Central Asia increased over the period 1976-2009, with Russia, Norway and Spain being the main exporters. Per capita consumption also increased, with Norway, Iceland, Spain, Portugal and Lithuania being the countries with the highest per capita consumption (Watson et al., 2015) (See Section 2.2.2.1).

Interregional flows of roundwood and wood products (t C per year) have changed patterns between 1997 and 2012 (**Figure 2.50**). The largest flows within Europe and Central Asia are exports from Central and Eastern Europe to Western Europe (stable between 1997 and 2012). Eastern Europe increased exports to South Asia. Flows from North America to Western Europe decreased, flows from Latin America to Western Europe increased.

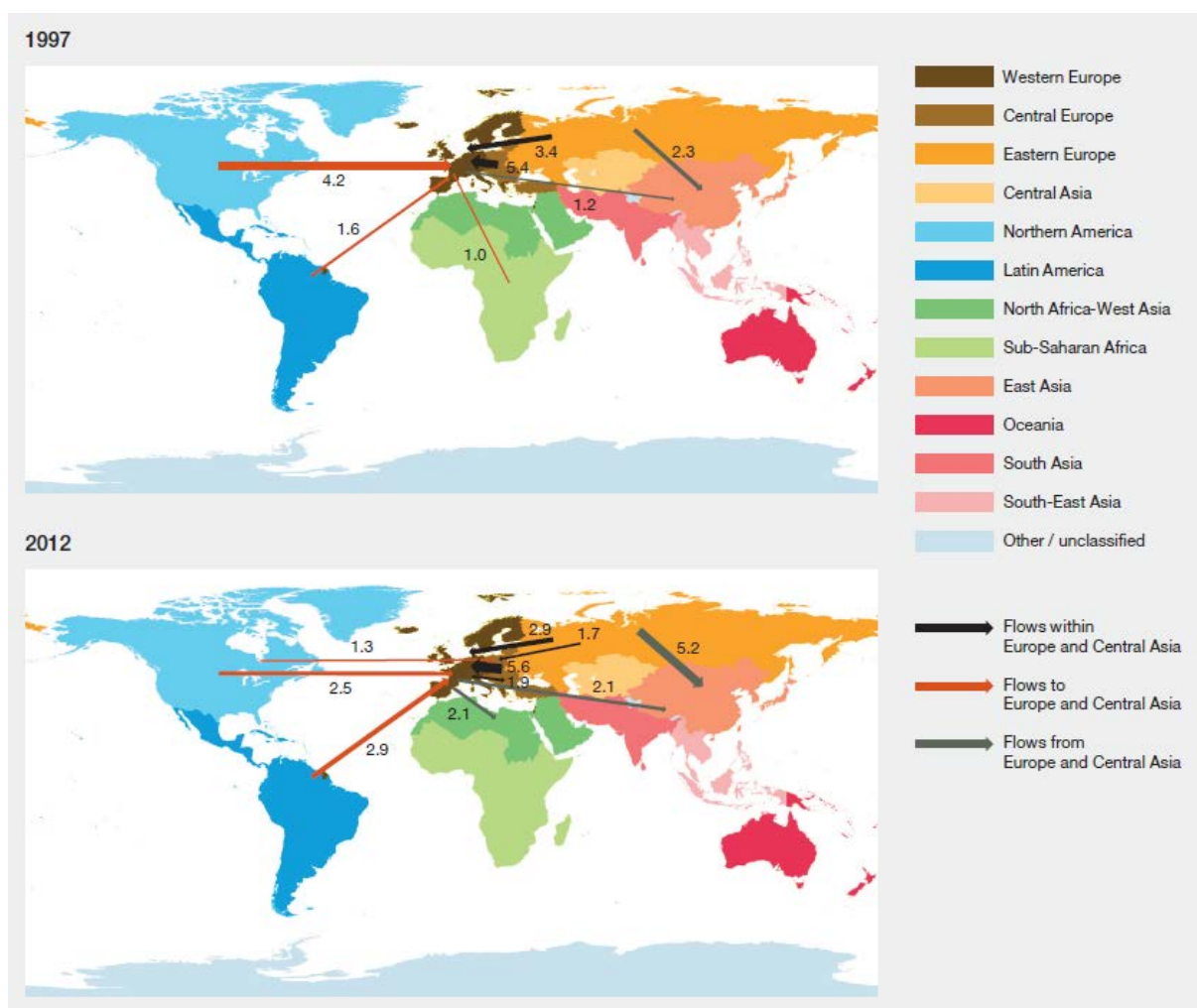


Figure 2.50: Flows of traded wood and wood products (million tonnes of C), within, to and from Europe and Central Asia for 1997 and 2012. Only flows above 1 million t C are indicated with arrows. Illustration based on data from Henders et al., 2015; Kastner et al. (2011).

Interregional flows take place also for carbon sequestration. There is evidence that terrestrial ecosystems only sequester a small fraction of anthropogenic carbon emissions in Europe (defined here as the landmass between the Atlantic Ocean and the Urals, excluding Turkey and the Mediterranean isles) (Janssens et al., 2003). The rest is sequestered by terrestrial ecosystems in other parts of the world, by oceans, or adds to the atmospheric carbon stock.

2.2.5 Summary of trends of nature's contributions to people

The contributions to people from ecosystems in Europe and Central Asia have changed markedly since the 1950s, promoting changes in the quality of life of its societies (see Section 2.3). Although the ecosystems of the region are currently delivering multiple contributions to people, there has been evidence of negative trends in the provision of regulating and some non-material contributions since the 1960s (see **Figure 2.51**). Overall, 58% of publications provide evidence of negative trends of nature's contributions to people provided between 1960 and 2016, while 28% reported positive trends (see electronic Appendix 2.7 for the whole list of references reporting increasing, constant, decreasing and mixed trends per contribution). This pattern, however, is not consistent across contributions: while 59% and 66% of the scientific publications reviewed provide evidence of declining

trends in regulating and non-material contributions, respectively, only 39% of the studies show negative trends in the delivery of material contributions (**Figure 2.51**). In fact, of the range of nature's contributions to people delivered in Europe and Central Asia, about 44% have been assessed as declining, particularly regulating and some non-material contributions, such as learning derived from indigenous and local knowledge. The decreasing trends of learning derived from indigenous and local knowledge also have consequences for other contributions from nature to people, such as the use of medicinal plants (Section 2.2.2.4), wild food gathering (Section 2.2.3.2.1), the use of guard dogs for protecting livestock (Section 2.2.2.3.4) and the cultural identity of peasants, herders and shepherds (Section 2.3.3, electronic Appendix 2.2), which have also declined over the assessed period.

Intensification of management practices, technology, manufactured capital and market forces have promoted increasing trends in the provision of particular material contributions from nature to people, including food, biomass-based energy and materials (**Figure 2.51**). The increasing trends in the delivery of specific material contributions have come at the expense of the long-term deterioration of regulating contributions. Some key regulating contributions, such as habitat maintenance, pollination, regulation of freshwater quantity and quality, formation and protection of soils, and regulation of floods, have been negatively affected since the 1960s by intensified management practices that seek to increase production of crops, livestock, aquaculture, woodfuels and cotton. In addition, the increasing demand in Western and Central Europe for nature's material contributions to people, such as food and biofuels, is straining the capacity of ecosystems and nature's contributions to people in other regions of the world (Sections 2.2.2.3 and 2.2.4).

The improvement found for some of nature's regulating contributions to people in the last decade in Western and Central Europe (see **Figure 2.51**), such as regulation of water quality, protection of soils and removal of animal carcasses by scavengers, can be explained by the successful implementation of European Union policies, such as the Nitrates and Water Framework Directives (see Section 2.2.1.7) and the Common Agricultural Policy (see Section 2.2.1.8), the implementation of different nature-based solutions for water quality (see Section 2.2.1.7), as well as different conservation programs for vertebrates (see Section 2.2.1.10). In addition, it is worth noting that water-based regulating contributions from nature to people have improved in Western Europe since the 1990s due to changing patterns in societal behaviour driven by European Union policies, but not because of an enhancement in ecosystems' capacity to provide them. For example, although water quality is improving due to the aforementioned Union policies and pollution reduction, ecosystems' capacity to regulate water quality has been jeopardized by a reduction in the areal extent of wetlands and floodplains (see Section 2.2.1.7). The abstraction and use of freshwater have decreased since the 1990s; however, water availability per capita has also decreased by 15% since 1990 (see Sections 2.2.1.6, 2.3.1.3). Similarly, the increasing trends of physical and psychological experiences (see **Figure 2.51**) can be explained by the fact that people in the European Union have increasingly demanded nature for recreational activities, although land-use change has threatened the ecosystems highly valued by people for these experiences (see Section 2.2.3.2.1).

The pattern of trends in nature's contributions to people is consistent across the subregions of Europe and Central Asia (**Figure 2.51**). Declining trends of these contributions are reported in Central Europe (61% of the scientific evidence), Western Europe (55%), Eastern Europe (54%) and Central Asia (48%); while increasing trends are mostly reported for Western Europe (35% of scientific evidence). Nevertheless, it should be noted that more scientific research (in English language-journals) on nature's contributions to people has been conducted in Western and Central Europe than in Eastern Europe and Central Asia (Boerema et al., 2017), with implications for the levels of confidence about status and trends of nature's contributions to people across subregions (**Figure 2.51**).

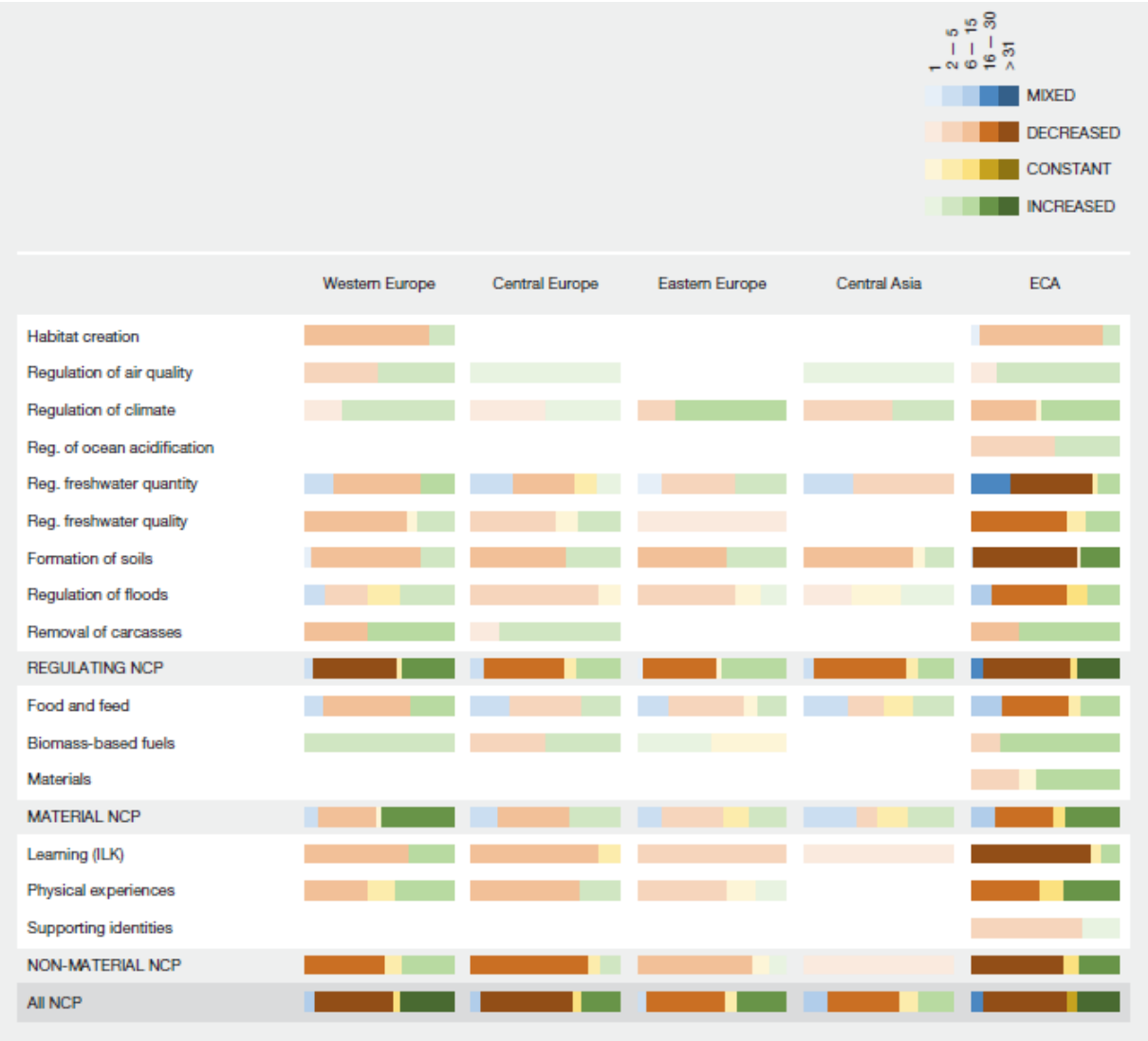


Figure 2.51: Assessment of each contributions from nature to people based on published literature for each subregion and for Europe and Central Asia as a whole. The bottom row of the panel shows the trends of all contributions. The bar indicates the proportion of papers that provide evidence of decreasing, constant, increasing or mixed trends for each contribution, representing the level of agreement. The intensity of the colour represents the total number of publications identified and used in this assessment (i.e., solid colours indicate many papers, whereas faded colours indicate few, and blank space indicates zero studies), thus, representing the quantity of evidence. The degree of confidence is also represented by indicating the level of agreement (i.e. the strongest agreement is presented when only one colour is shown) and the quantity of evidence (i.e. the most robust evidence is presented when the assessment is validated by more than 31 multiple independent papers, which is represented by dark solid colours). Colours can also vary for the same contribution when trends of contribution subtypes differ. See Appendix 2.7 for the list of references reporting trends in contributions across subregions of Europe and Central Asia.

2.2.6 Future trends in nature’s contributions to people

This section examines the potential impacts of individual drivers on future trends in nature’s contributions to people, with trends in direct and indirect drivers covered in Chapter 4 and the impacts of combined drivers and trade-offs between contributions discussed in Chapter 5 Sections 5.2 and 5.3.

A semi-structured literature review (see Section 2.2) was undertaken, with information extracted into a template to enable comparison across nature's contributions to people and to facilitate integration with Chapter 5's analysis of the impacts of multiple drivers on the status and trends of contributions (see Section 5.3.3 and 5.3.4). In the allotted time, this search process could only be fully applied to food and feed, air and climate regulation, and learning and inspiration. Even the targeted semi-structured literature review yielded comparatively few articles, except for Western Europe. Thus, it was not possible to estimate robustly future trends in nature's contributions to people in Europe and Central Asia. As in Chapter 4, the most frequently identified driver of trends in contributions was climate change, followed by land use, land-use change and forestry (LULCC).

2.2.6.1 *Regulating contributions*

Nature's regulating contributions to people are likely to show mixed responses to climate change across Europe and Central Asia (Kovats et al., 2014). Few studies have examined future trends in *pollination or pollinators*, but both qualitative and quantitative modelling studies suggest that climate change is likely to lead to pollinator decline. Modelling shifts in bumblebee distribution showed that, by 2100, up to 36% are projected to be at high risk from climate change (losing >80% of their current range), with 41% at risk (losing 50-80% of their current range), depending on the scenario (Kerr et al., 2015).

Little literature was found for the *air regulation* as a contribution from nature to people. Tallis et al. (2011) estimated that the planned increase in tree cover, from 20% to 30% in the Greater London Authority area, could increase particulate matter (PM₁₀) removal by 18% by 2050, assuming no change in tree cover types. Papers on past and present trends in urban air quality comment on the importance of trees and green space in the future (e.g. Baró et al. (2014)).

Climate regulation may become more important as countries seek to meet their greenhouse gas commitments under the Paris Agreement. For example, the Tajikistan government has a national programme on carbon sequestration (2014-2024), which includes plans for afforestation and reforestation (Mustaeva et al., 2015). For future carbon budgets, climate and land use, land-use change and forestry (LULCC) were the most frequently analyzed drivers, with the net balance of their effects depending on their impact on vegetation, soil storage and decomposition. In the Arctic, global mean temperature increases could decrease carbon storage in permafrost soils by 2100, despite increased uptake of carbon by vegetation. In northern parts of Western and Eastern Europe, warming could increase tree carbon storage (Olchev et al., 2009; Shanin et al., 2011), although it would decrease if precipitation declines (Olchev et al., 2009), especially in southern areas of the European Union (Lavalley et al., 2009). Also, forest disturbance from wind, bark beetles and wildfires are projected to decrease the carbon storage potential of forests in Western and Central Europe by 503.4 TgC between 2021–2030 (Seidl, 2014).

Land use change and fire could have mixed effects on future *carbon budgets* (Kuemmerle et al., 2011; Verkerk et al., 2014). Unmanaged woodlands in Western Europe should continue to be a carbon sink (Allen et al., 2016), while in central Russian forests, fire and management could have a greater influence than climate on future vegetation and soil carbon stocks, with forests becoming a carbon source rather than a sink (Shanin et al., 2011). There are similar mixed responses to land use change and management on formerly abandoned lands in Eastern Europe and Central Asia (Causarano et al., 2011), with afforestation increasing carbon storage, while for biofuel production, using low intensity/high density grass-legume pastures, it depends on the timing of cultivation, tillage and

climate change, and soil carbon sequestration would increase unless climate change were to decrease vegetation net primary productivity (Vuichard et al., 2008).

Artificialization and soil sealing are rapidly increasing in the European Union (FAO, 2015b; Jones et al., 2012) and might affect the *formation and protection of soils* as a contribution from nature to people in the near future, while this is not yet a problem in Central Asia due to the vast extent of land (UNEP/UNECE, 2016). Hence, the supply of erosion control in the coming decades will mainly depend on the farming practices and land-use policies implemented.

Changes in climate will affect the demand for, and supply of, *hazard regulation*. Greater demand could result from increased glacier melt (Hagg et al., 2006; Sorg et al., 2012; Stoffel & Huggel, 2012); flooding due to heavy precipitation events in parts of Western and Central Europe (Kovats et al., 2014); and fire frequency and severity, especially in parts of Russia (Gauthier et al., 2015) and southern Western Europe, where the annual burned area could increase by a factor of three to five by 2100 under the IPCC A2 emission scenario (Dury et al., 2011).

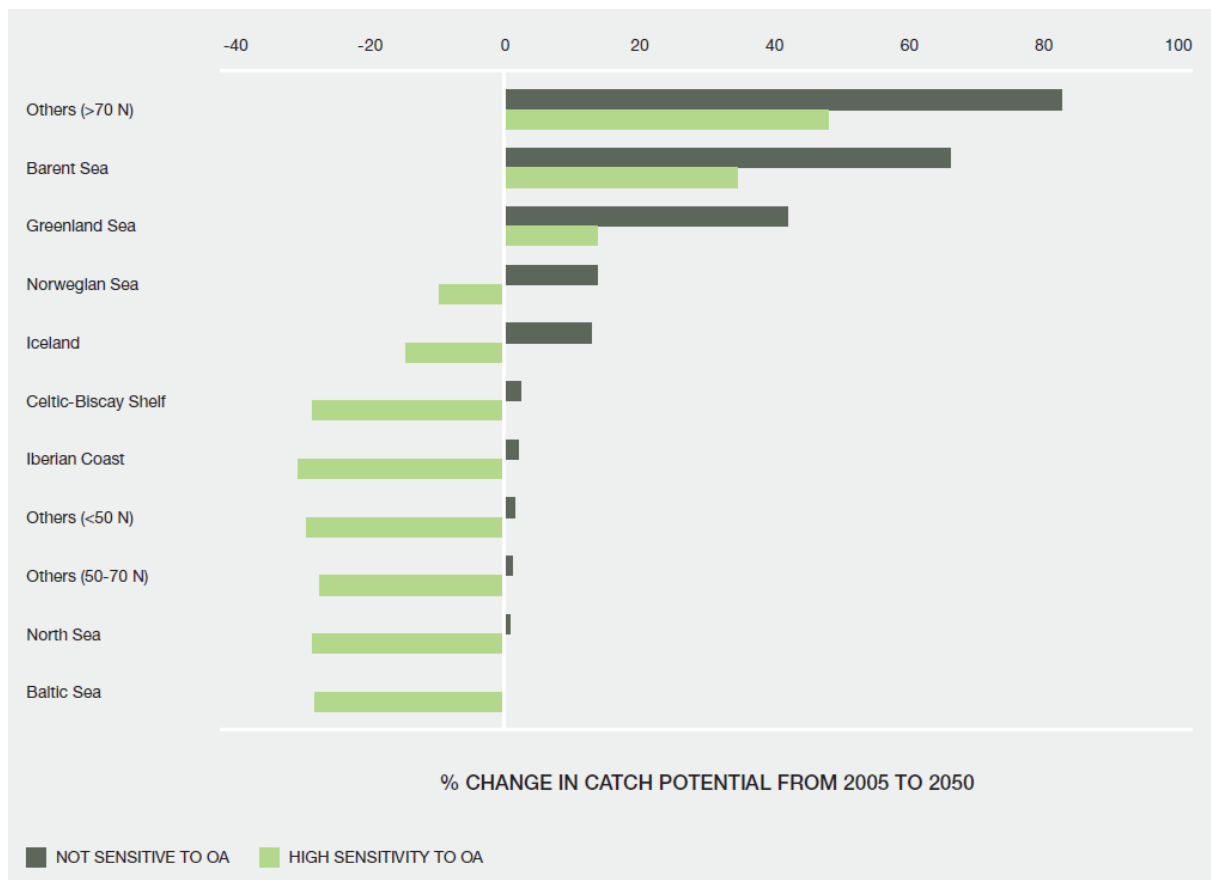
2.2.6.2 *Material contributions from nature to people*

Changes in seasonal, and extremes of, temperature and precipitation, as well as CO₂, can affect *food and feed* provision, which show mixed trends in yield, depending on the scenario, region and crop. Global modelling of cereal production in 2050 shows increases in countries in the Organization for Economic Co-operation and Development and in countries emerging from the former Soviet Union, partly as a result of an enhanced CO₂ fertilization effect, with cereal consumption possibly increasing in the former, and increasing in the latter depending on scenario (Alcamo et al., 2005). Zabel et al. (2014) also suggest that climate change will increase the extent of agriculturally suitable land and food production in Russia. Food, livestock and fibre production, however, are projected to decrease in parts of Western and Central Europe, but to increase in the northern parts of these regions (Kovats et al., 2014). Climate change is projected to cause increased yields of rainfed maize, while rainfed wheat shows a mixed response across Europe and Central Asia, depending on the climate scenario (Nelson et al., 2010). It could lead to an overall decrease in daily per capita calories available (Nelson et al., 2009) and in fodder quality (Quetier et al., 2007). In Eastern Europe and Central Asia, by 2050, yields of many irrigated crops show a mixed response, but water shortages mean that irrigation is unlikely to be able to continue at current levels, so yields could decrease by 50% or more (Sutton et al., 2013). Other studies project decreases in agricultural production from combined effects of climate change and deteriorating land use practices in the Czech Republic (Lorencova et al., 2013) and across Western Europe (Haines-Young et al., 2012).

Timber production may decrease in many parts of Central Europe, but with increases predicted in northern parts of Western Europe. In Finland, forest stand models, in which tree growth is converted into site and then regional forest growth, calculate that, under an Intergovernmental Platform on Climate Change SRES B2 scenario (based on the Special Report on Emissions Scenarios (SRES)), pine growth in southern Finland could increase by 16% and in Lapland by 31%, while under a higher (SRES A2) emissions scenario these figures are 40% and 80% respectively (Forsius et al., 2013).

In the EU-27, demand for *biomass-based wood for energy*, and wood products are both projected to increase from 2010 to 2030 under a *global markets* scenario (Verkerk et al., 2014), but the production and consumption of wood products is lower and could slow under the *regional sustainability* scenario (Jonsson, 2013), with Eastern Europe accounting for a greater proportion of production and consumption of solid wood, pulp and paper products. The increasing demand, especially for wood-based energy, means that EU-27 supply may not meet the future demand for raw wood materials.

4683 For fish production, the maximum catch potential could increase in Western Europe, especially in high
 4684 latitude seas (>50°N), with an average yield increase of 30-70% (**Figure 2.52**), depending on
 4685 assumptions about the effects of ocean acidification on fish ecophysiology (Cheung et al., 2012).



4686

4687 **Figure 2.52: Projected changes in maximum catch potential by 2050 relative to 2005 under the SRES**
 4688 **A1B scenario, with assumptions about sensitivity to ocean acidification (OA). Projections are made**
 4689 **using a dynamic bioclimatic envelope model with physical and biogeochemical outputs from the**
 4690 **National Oceanic and Atmospheric Administration's Geophysical Fluid Dynamics Laboratory Earth**
 4691 **System model (TOPAZ). From Cheung et al. (2012).**

4692 Within Europe and Central Asia, the main biodiesel and bioethanol producers and consumers are
 4693 within the European Union. Based on the Special Report on Emission Scenarios (Nakicenovic & Swart,
 4694 2000), the scenarios for the spatial allocation of *biofuel crops* within the EU-27 region showed that by
 4695 2030, for different storylines with various political and economic circumstances, some regions are
 4696 projected to have a higher share of biofuel crops (Hellmann & Verburg, 2010) (**Figure 2.53**).

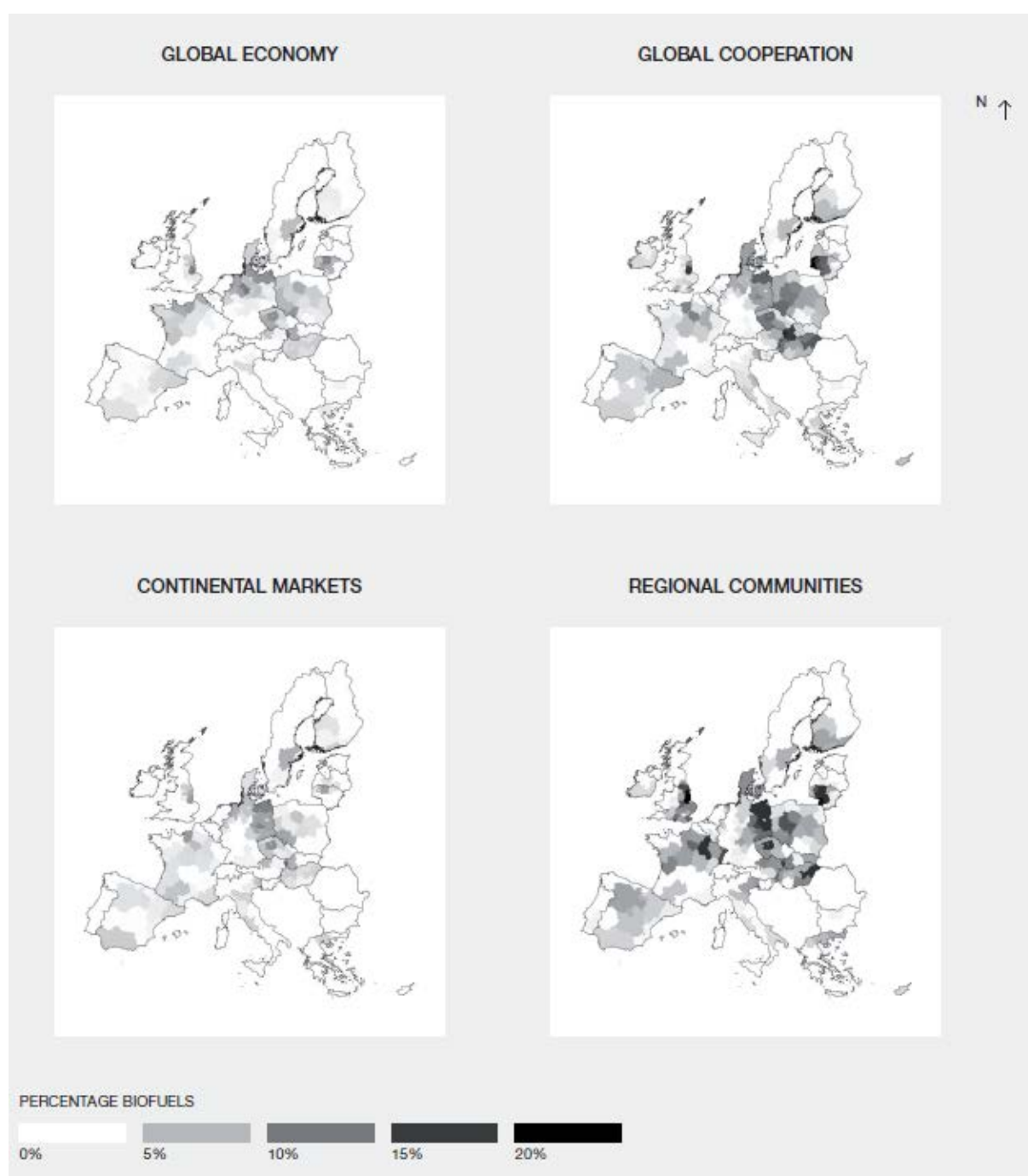


Figure 2.53: Biodiesel and ethanol production in the European Union (EU-27) by 2030 under different scenarios combining drivers such as globalization and regionalization, import levels, processing facilities and infrastructural arrangements, subsidy levels, and nature conservation policies. Source: Hellmann & Verburg (2011).

For 2050 under a *business-as-usual* scenario, biofuel potential amounts annually to 3.6 EJ (Western Europe), 6.3 EJ (Central Europe), and 7.9 EJ (Central Asia and Russian Federation) (Haberl et al., 2011). **Figure 2.53** shows that current biofuel production in the subregions is strongly below the future potential. Western Europe has the lowest potential, but the significantly highest biofuel production. However, these biofuel potentials do not take changes in population, diets, and climate into account. The highest unused potentials for biofuels are in Central Asia and Russia.

2.2.6.3 Nature's non-material contributions to people

There are fewer studies on the future of nature's non-material contributions to people and most of them relate to learning and inspiration and physical and psychological experiences linked to outdoor recreation and tourism. In northern Scandinavia and north-western Russia, tourism and recreation could decrease in winter due to climate change, but increase in summer, while cultural ties to the landscape and species unique to northern areas could decline (Forsius et al., 2013; Jansson et al., 2015).

Verkerk et al. (2014) showed that recreational attractiveness (an expert-based index (1–10) of the preference value for different forest stands for recreation) did not change in Western or Central Europe in either a reference (*business as usual*) scenario or wood energy scenario (see above). The biodiversity scenario, however, could lead to an improvement in the recreational attractiveness index by 0.5 points (+ 9.4%; range between countries: + 0.2 to +1.0 points). Overall, the changes were quite small as the index depends on broad age classes of people, which changed relatively slowly between 2010 and 2030.

No clear evidence of future trends in learning and inspiration from nature can be identified, but knowledge of urban habitats can contribute to future urban greening policy and scenario development (Camps-Calvet et al., 2015; Colding et al., 2013; Mortberg et al., 2013). Scientific and indigenous and local knowledge of a range of nature's contributions to people is a key component of scenario development used to consider future strategies and options for environmental and conservation management, such as for transhumance networks in Spain (Oteros-Rozas et al., 2013a), forests in Poland and Sweden (Carlsson et al., 2015; Chmura et al., 2010) and protected areas in Europe (Mattsson & Vacik, 2017). Emerging forms of learning, using virtual tools to develop environmental awareness amongst adults and young people will also rely on knowledge of biodiversity and drivers of change (Harwood et al., 2015; Ulbrich et al., 2015).

For many of nature's contributions to people, policies can also affect the future demand and supply. Simulations of how land use changes in the EU-27 could affect a range of contributions under a *business-as-usual* scenario and three biodiversity *no net loss* scenarios were undertaken by Schulp et al. (2016). The simulations found that while *no net loss* policies generally led to an improvement in most of nature's contributions to people, especially climate regulation and pollination, such policies would not totally address the loss of biodiversity and of nature's contributions to people because of the continued demand for land for human use (**Figure 2.54**). Food provisioning could also be negatively affected under *no net loss* policies, while some of nature's regulating contributions to people and recreation could be little affected.

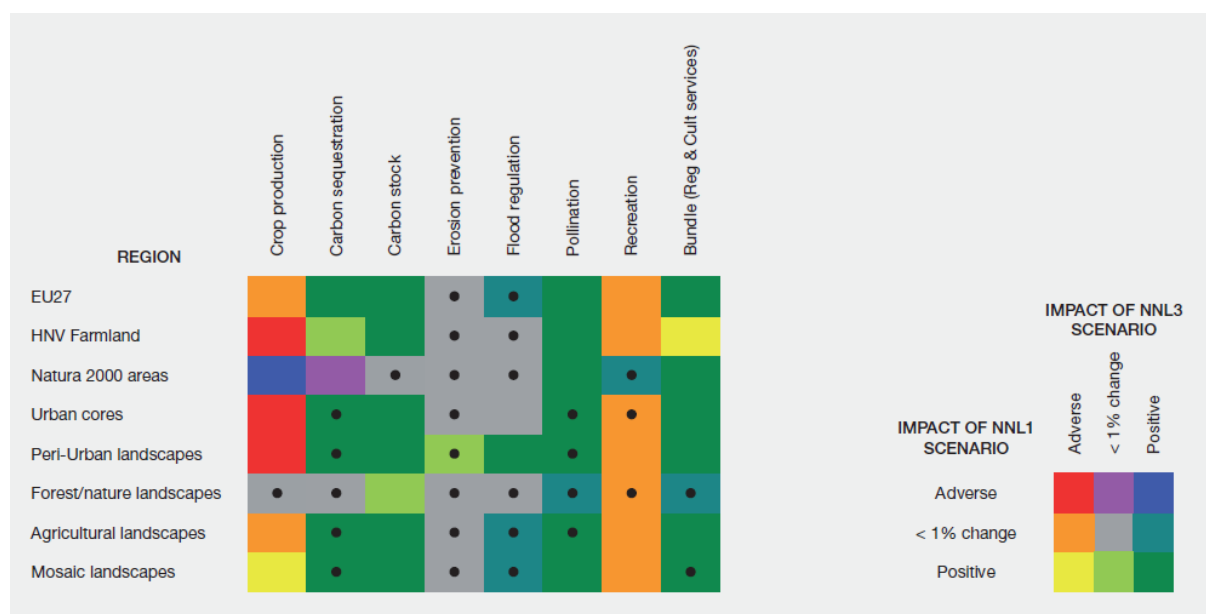


Figure 2.54: A comparison of changes in nature's contributions to people in different landscape types under a *no net loss* scenario with better implementation of existing biodiversity conservation measures (NNL1) and a *no net loss* scenario with offsetting of residual impacts on areas of high biodiversity and ecosystem service value (NNL3), compared to Business-as-Usual. * indicates no net loss of the contributions from nature to people compared to baseline under the NNL3 scenario. From: Schulp et al. (2016).

This, and other studies which consider a number of nature's contributions to people together (e.g. Kain et al. (2016)), highlight that trade-offs between contributions need to be taken into account when considering both current and future trends (Section 2.3.4.2).

2.3 Effects of trends in nature's contributions on quality of life in Europe and Central Asia

2.3.1 Contributions to food-energy-water security

Food, energy and water are essential for human wellbeing, poverty alleviation and sustainable development (FAO, 2014b). Food security, water security and energy security represent Sustainable Development Goals number 2, 6 and 7, respectively (see Section 2.4).

2.3.1.1 Food security

Food security is achieved when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO, 2014b). A condition for the full realization of the right to food is "food sovereignty" (De Schutter, 2014), defined as "the right of nations and peoples to control their own food systems, including their own markets, production modes, food cultures and environments" (Wittman et al., 2010). The situation and trends of food security and sovereignty in Europe and Central Asia have been mixed in the last century and vary greatly between and within subregions, with the best situation in Western Europe, and Central Asia showing the largest challenges (all data retrieved from FAOSTAT).

Food availability is adequate across Europe and Central Asia, where the average dietary energy supply adequacy ranges from 137% in Western Europe to 121% in Central Asia (see **Figure 2.55**). Food accessibility and utilization varies between subregions. The domestic food price level showed stability between 2001 and 2014, but also large inequalities within the region with the lowest price levels in Western Europe, intermediate levels and decreasing in Central Europe, and three times higher levels and increasing in Eastern Europe. Undernourishment has been very low in recent decades in Central and Western Europe; in Eastern Europe, although currently stable around 7%, it reached almost 45% in the early 1990s; and in Central Asia, it has fluctuated and currently reaches 20%. The percentage of adults who are underweight increased to almost 4% in Central and Western Europe from the late 1990s to the end of the century. During the recession of 2007-2009 daily nutritional intake and the consumption of nutritious food declined in Eastern and Central Europe, so that after 2008 the percentage of households with children unable to afford a meal with meat, chicken, fish, or a vegetable equivalent every second day more than doubled in some countries reaching up to 18% in Greece in 2012 (UNICEF, 2014). Overall food stability is improving: domestic food price volatility is quite low and relatively stable in the last decades, except for a peak in Eastern Europe in 2005. However, the food production variability per capita is increasing since 2010, particularly in Eastern Europe, which might be considered a threat to food security. A global nutrition transition is affecting the quality of diet in Europe and Central Asia (see **Figure 2.56**), with rapid increases in the rates of obesity and overweight (Popkin et al., 2011), which is linked to inefficiencies and waste in the global food system. In fact, the average fat supply and protein supply are increasing and the former is almost double in Western Europe than in Central Asia and Eastern Europe, which instead show the largest index of diet diversification (see **Figure 2.56**). The prevalence of food over-acquisition is almost 50% in Western Europe and, although it is lower in the other subregions, it is increasing for these.

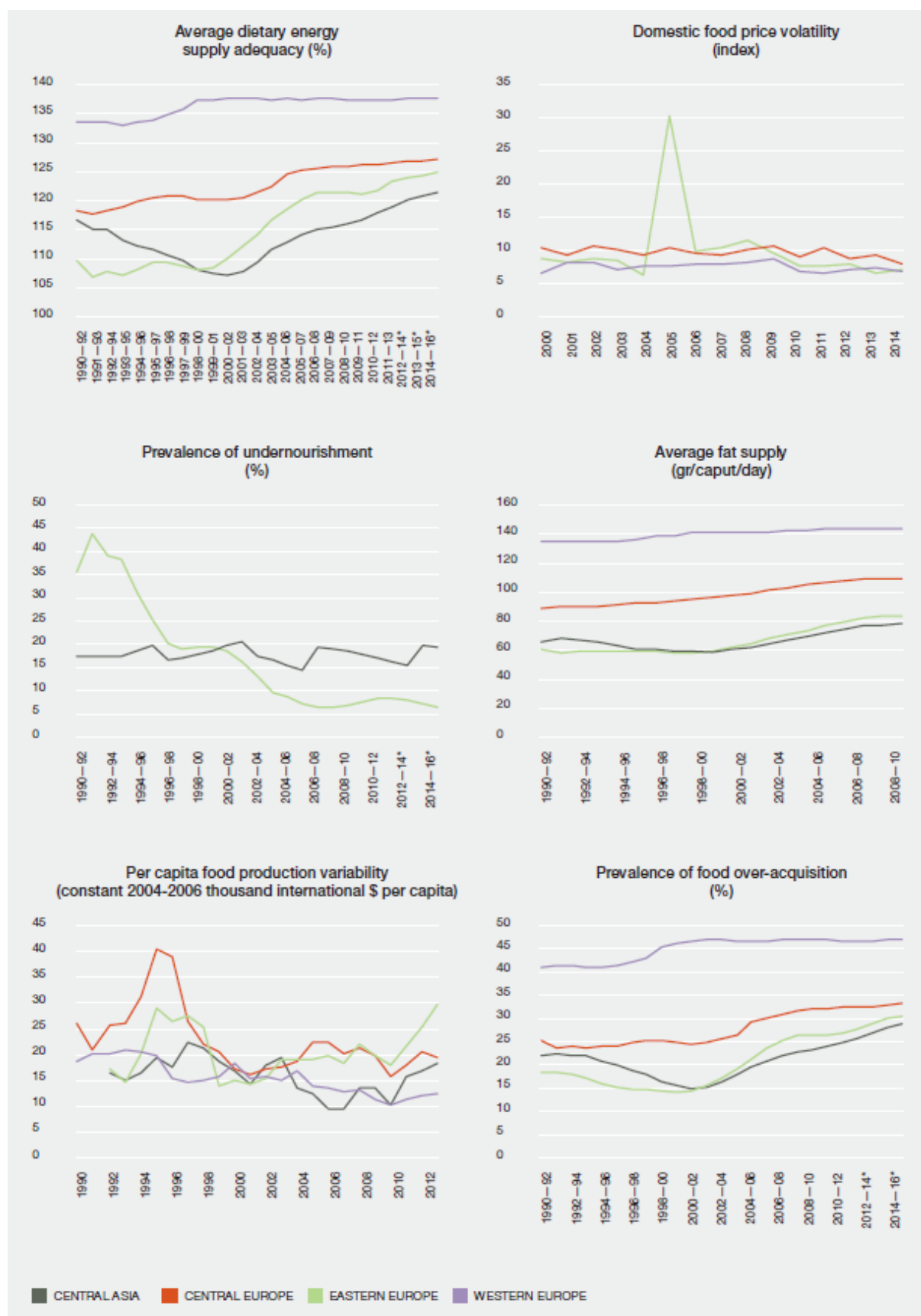
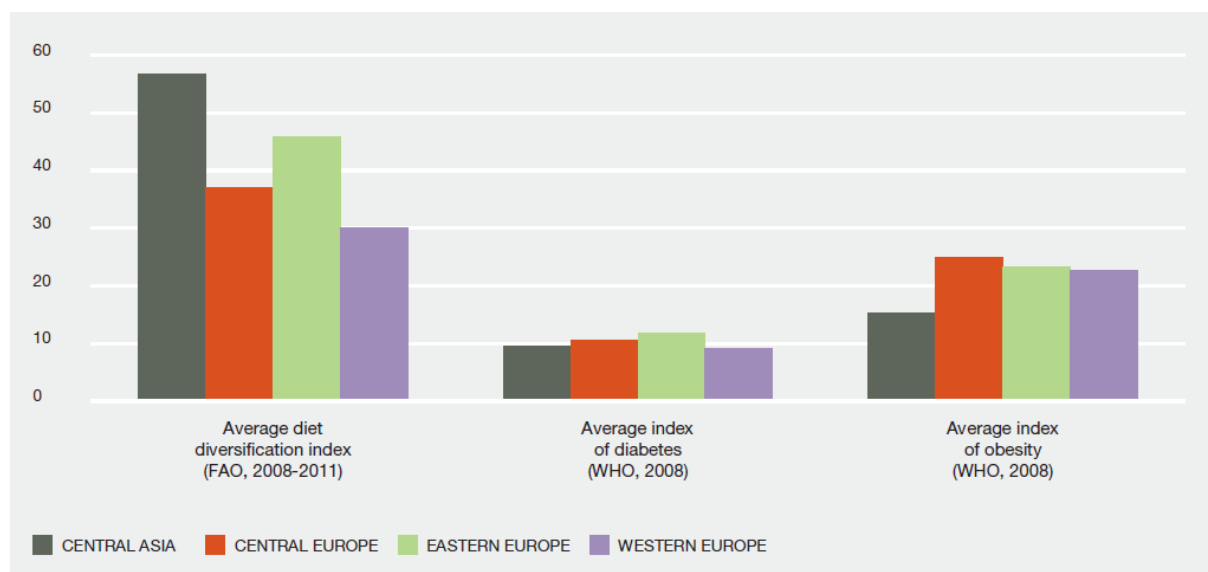


Figure 2.55: Trends in indicators of food security for Europe and Central Asia: blue represents Central Asia; red represents Central Europe; green represents Eastern Europe; and purple represents Western Europe. Source: own elaboration with data from FAOSTAT.

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4797

4798 **Figure 2.56: Average indices of the quality of the diet and its impacts on health in subregions of**
 4799 **Europe and Central Asia. Source: own elaboration with data from OXFAM.**

4800 Food security and food sovereignty are threatened by large-scale control of extended tracts of land
 4801 by large investment companies (land deals or land grabs) (van der Ploeg et al., 2015). In 2012 there
 4802 were 51 documented cases in Europe and Central Asia occupying a total area of 4.4 million ha (see
 4803 **Figure 2.57**): Russia, Ukraine and Romania are the countries with the largest land-grabbed areas
 4804 (GRAIN, 2016). Countries from the region are also grabbing land abroad (0.63% of worldwide
 4805 croplands), particularly Western Europe countries (0.57% of worldwide croplands). However, official
 4806 statistics do not capture the real dimensions of the phenomenon, which leads to crop production
 4807 being intensified and oriented to distant markets other than local needs (TNI, 2016). Finally, both food
 4808 security and sovereignty are challenged by the loss of agri-food related indigenous and local
 4809 knowledge and agrobiodiversity (see Chapter 3 and **Box 2.2**).

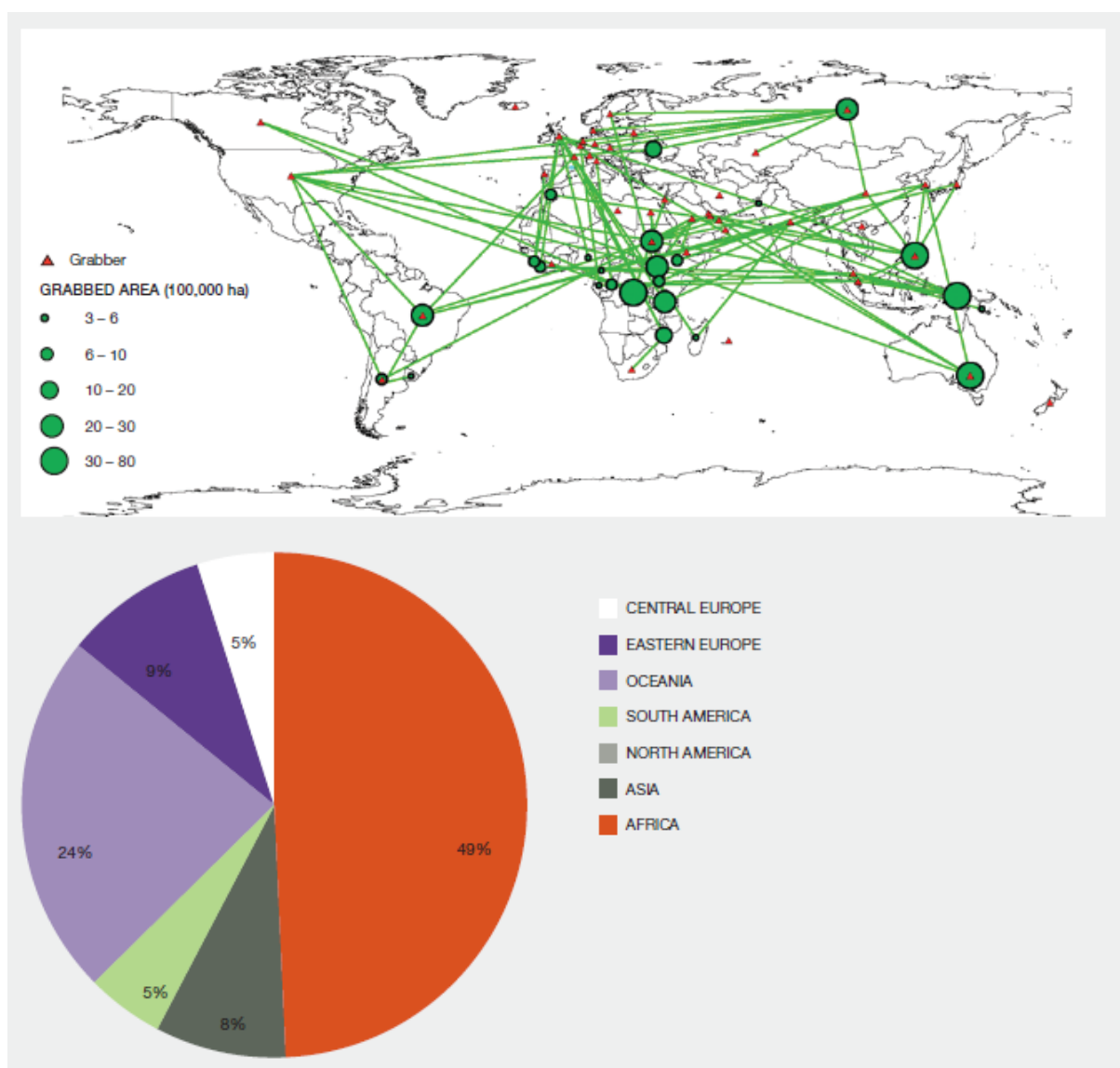


Figure 2.57: Top: A global map of the large-scale acquisitions of land (also known as land-grabbing) network: land-grabbed countries (green disks) are connected to their grabbers (red 2068 triangles) by a network link. Source: Rulli et al. (2013). Bottom: Percentage of surface grabbed by Western Europe in each subregion in Europe and Central Asia and world regions.

Box 2.2: Custodians of food, seeds and traditions: biocultural diversity – the diversity exhibited collectively by natural and cultural systems - of people in the Pamir mountains of Tajikistan.

“Lonely, desolate, and inhospitable as these mountains for the most part are, one may still find secluded valleys cut deep down into the mountain masses where some hardy hill-men till the ground and form villages.”

The remote plains of the Pamir mountains are a challenging place to transform rock into life-giving soil, primarily rain-fed. Yet, that is what Pamiri people have done over millennia at between 2,000 and 4,000 metres, nurturing a centre of origin for grain and fruit varieties which have become staple crops all around the world, along with domesticated varieties of walnuts, apples, pears, apricots and mulberries.

The rich agrobiodiversity of the Pamirs co-evolved with language, culture and spirituality, and as a result of local cooking traditions. Food embodies the interconnectedness of sustenance, health, spirituality, and ecosystem structure and function. *Baht*, a sweet festive porridge of flour and ice water, that is made in celebration of the

4827 new year, *Nawruz*, exemplifies these interconnections. The isolated Bartang Valley is well-known for the
4828 sweetest tasting *Baht*, because of a variety of wheat called *rush-kakht*, which is grown only in the upper reaches
4829 of the valley with the sole purpose to make *baht*. Women use small amounts of the flour of *rush-kakht* to bless
4830 the pillars of the house for a productive new year.



4831
4832 Red wheat growing in Bartang valley. During *Nawruz*, little animals made of bread (*Nazrak*) are covered in *Baht*
4833 and provided as offerings.

This text box is based on van Oudenhoven & Haider (2015)

End of Box 2.2

2.3.1.2 Energy security

Energy security has been defined by the United Nations as “access to clean, reliable and affordable energy services for cooking and heating, lighting, communications and productive uses” and by the International Energy Agency as “uninterrupted physical availability (of energy) at a price which is affordable, while respecting environment concerns”. Energy production was highest in Eastern Europe and lowest in Central Europe in 2014 (see **Figure 2.58**). For heating, “energy poverty” affects at least 10% of the population and is more likely for low-income groups in the European Union (see **Figure 2.60**). Energy poverty is more pronounced in Eastern Europe (Dubois & Meier, 2016).

The highest share of bioenergy (biofuels and waste) relative to the total production in the region is produced in Western and Central Europe. The highest share of hydropower relative to total production is produced in Western and Eastern Europe. Western Europe is a net importer of fossil energy carriers (coal, oil products, and natural gas), whereas Eastern Europe is the largest, and Central Asia the second largest exporter in the region. The net imports or exports by subregion are negligible for bioenergy (biofuels and waste) and other renewables compared with other energy carriers (see **Figure 2.59**).

At the country levels, the trade balance for biofuels in Central Asia and Eastern Europe are mostly equalized. Net exporters are mostly found in Western and Central Europe, the biggest being The Netherlands, Latvia and Germany. Similarly, Western European countries also strongly depend on imports (Italy, the United Kingdom, Denmark, Austria, and Belgium) (see **Figure 2.61**).

Currently, biomass supplies in the European Union are mostly based on domestic sources (4% of the biomass for bioenergy imported) (European Commission, 2014b). In scenarios for 2020 and 2030, biomass for bioenergy may even fill other supply shortages for industry, replacing coal power plants (Dafnomilis et al., 2017).

In total, the actual contribution of bioenergy to energy security is weakly captured in existing research (Popp et al., 2014), as the multitude of biomass sources, energy carriers, and conversion pathways impede tracking of this renewable energy source. In addition, there are not only rather novel bioenergy carriers such as biofuels, but also woodfuels, which are extensively used, but roughly estimated in statistics of the United Nations Food and Agriculture Organization. This is especially a problem for the numerous countries analyzed in Eastern Europe and Central Asia. The countries of Central Asia have a negligible share of bioenergy in their energy supply (see **Figure 2.58**). However, given the difficulties of affordable and reliable access, the use of biomass from traditional sources such as charcoal is weakly accounted for, which might be an indication that the figures underestimated nature’s contributions to people from bioenergy (biofuels and waste) in this region (IEA/OECD, 2015).

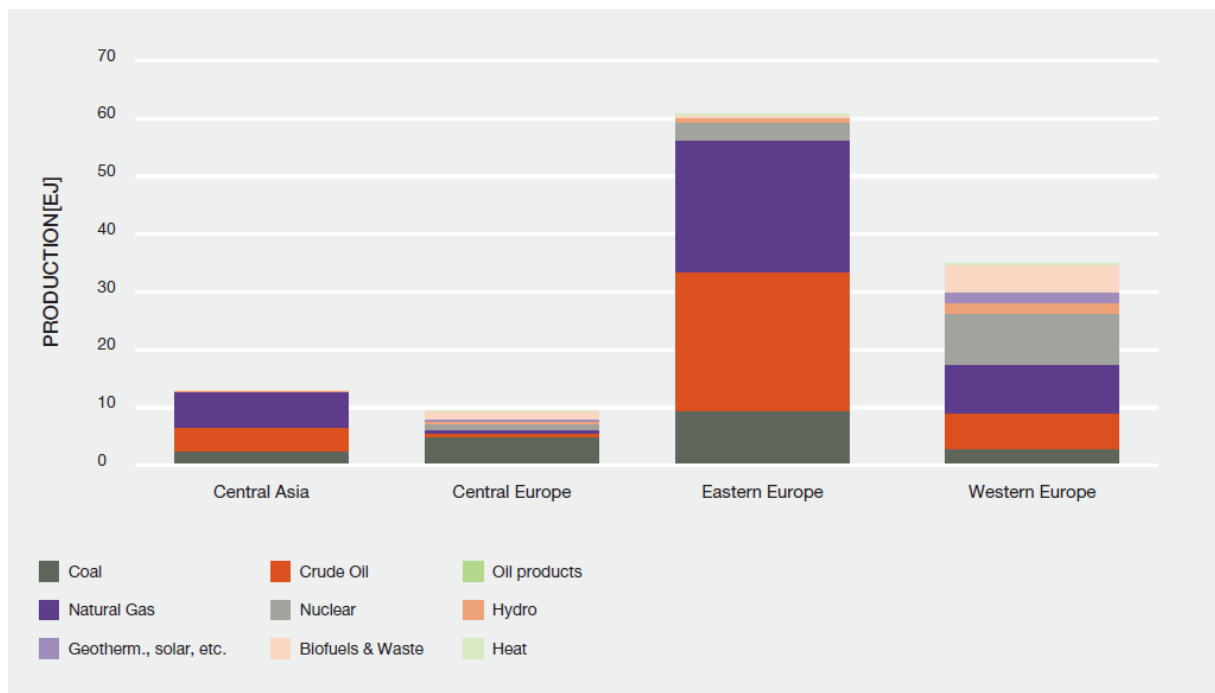


Figure 2.58: Energy production (in exajoule) by energy source and region in Europe and Central Asia (2014). Own representation based on: (IEA/OECD, 2016).

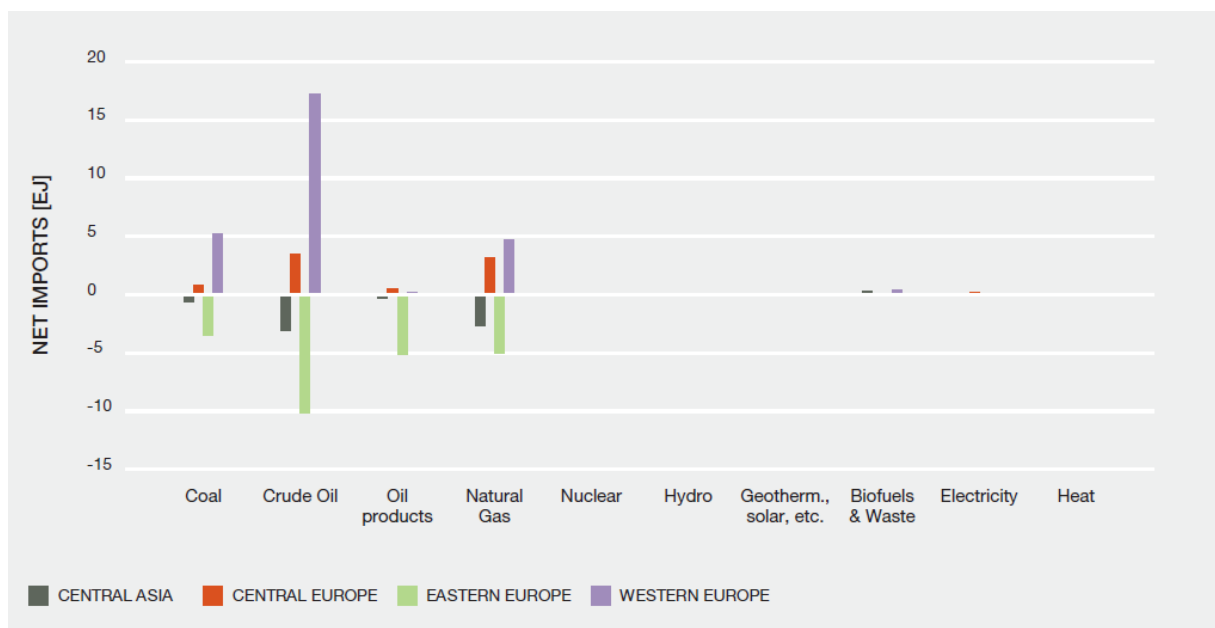


Figure 2.59: Net energy imports (in exajoules) by energy carrier and region in Europe and Central Asia (2014) (uncorrected for intra-regional trade). Own representation based on: (IEA/OECD, 2016).

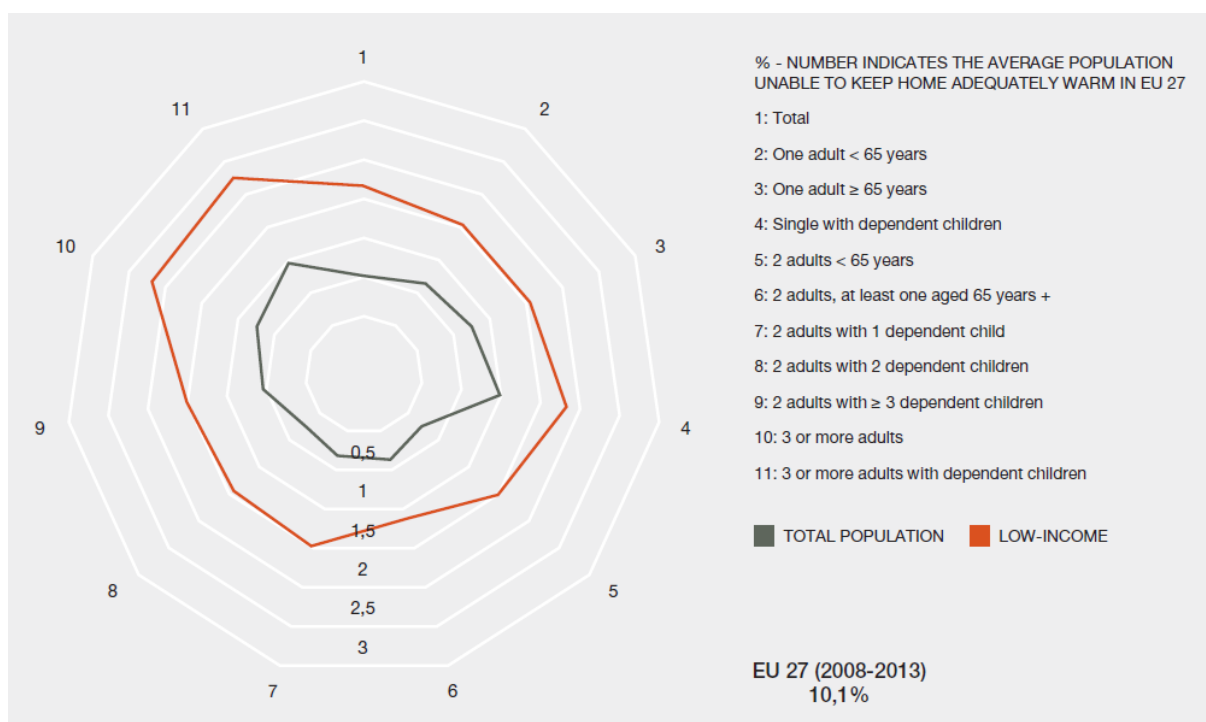


Figure 2.60: Inequality in access to heating in the EU-27. Source: (Dubois & Meier, 2016).

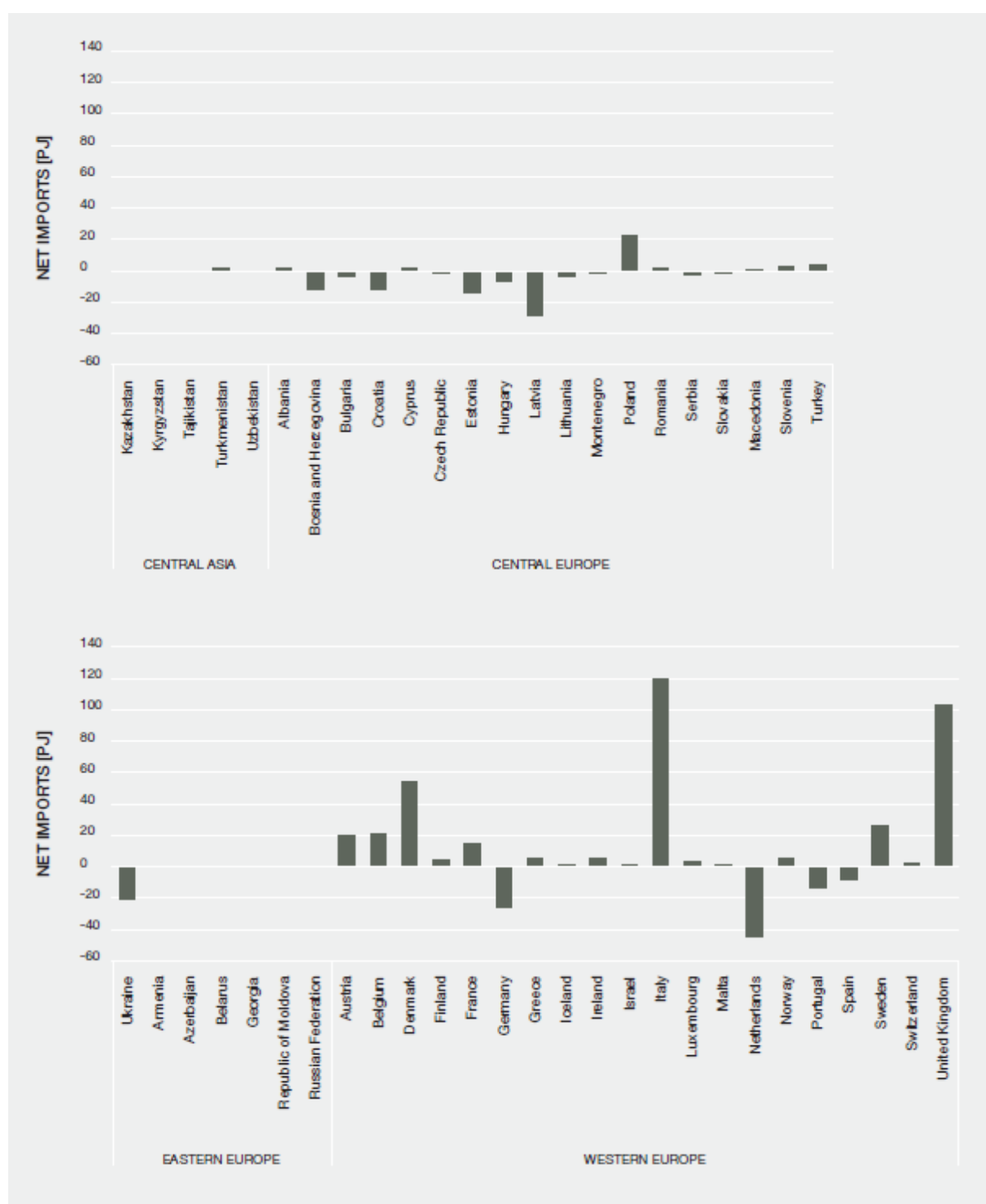


Figure 2.61: Net imports of biofuels and waste by country (2014) (uncorrected for intra-regional trade). Own representation based on: (IEA/OECD, 2016).

2.3.1.3 Water security

Water security is assessed here as people's capacity to safeguard sustainable access to adequate quantities of water of acceptable quality (UN-Water, 2013). The indicators "percentage of population with access to improved drinking water sources" and "freshwater withdrawal as percentage of total renewable water resources" are used to describe general trends for water security in Europe and

Central Asia. The former identifies adequate water availability of improved quality (World Bank, 2016), the latter reveals the extent to which long-term available water resources are exploited (FAO, 2016).

Overall, water security has increased in the region since the late 1980s (Animesh et al., 2016; FAO, 2016; World Bank, 2016). Safe drinking water is secured for 95% of the Europe and Central Asian population, with higher percentages in Western Europe and Central Europe, while Eastern Europe (95%) and Central Asia (85%) have lower, but increasing access to improved drinking water since 1995 (see **Figure 2.62**). The trend in per capita water consumption has increased in all regions, due to increased population, except in Eastern Europe and Central Asia (Kummu et al., 2016). On-going water pollution, especially in Eastern Europe and Central Asia, continues to threaten the availability of safe drinking water, while decreased water levels in natural reservoirs have led to increased water pollution (UN-Water, 2011). Freshwater extraction as a percentage of total renewable water resources decreased between 1993 and 2012 for the Europe and Central Asia region, most notably for Western Europe and Central Asia (see **Figure 2.62**). It coincides with a 15% decrease in water availability per capita since 1990 (see Section 2.2.1.5).

Although water is generally abundant in the European Union, droughts and over-exploitation have led to seasonal water scarcity in some water basins, especially in densely populated and agricultural areas (EEA, 2015d, 2016f; Karabulut et al., 2016). Water stress in most countries of the European Union has decreased slightly since the 1990s, but many areas are considered close to being water scarce (EEA, 2011). In winter, around 6% of the European Union's population live under waterstressed conditions, while the figure is 14% in summer (EEA, 2016). Around 20 river basin districts, including the Danube basin but mainly in the Mediterranean region, face structural water stress issues (EEA, 2016g), due to climate change and unsustainable water extraction (Skoulidakis et al., 2017). The spatial coverage of freshwater ecosystems in the European Union with a good ecological quality, which are crucial for providing clean water, has decreased from 42% to 32% (see Section 2.2.1.6).

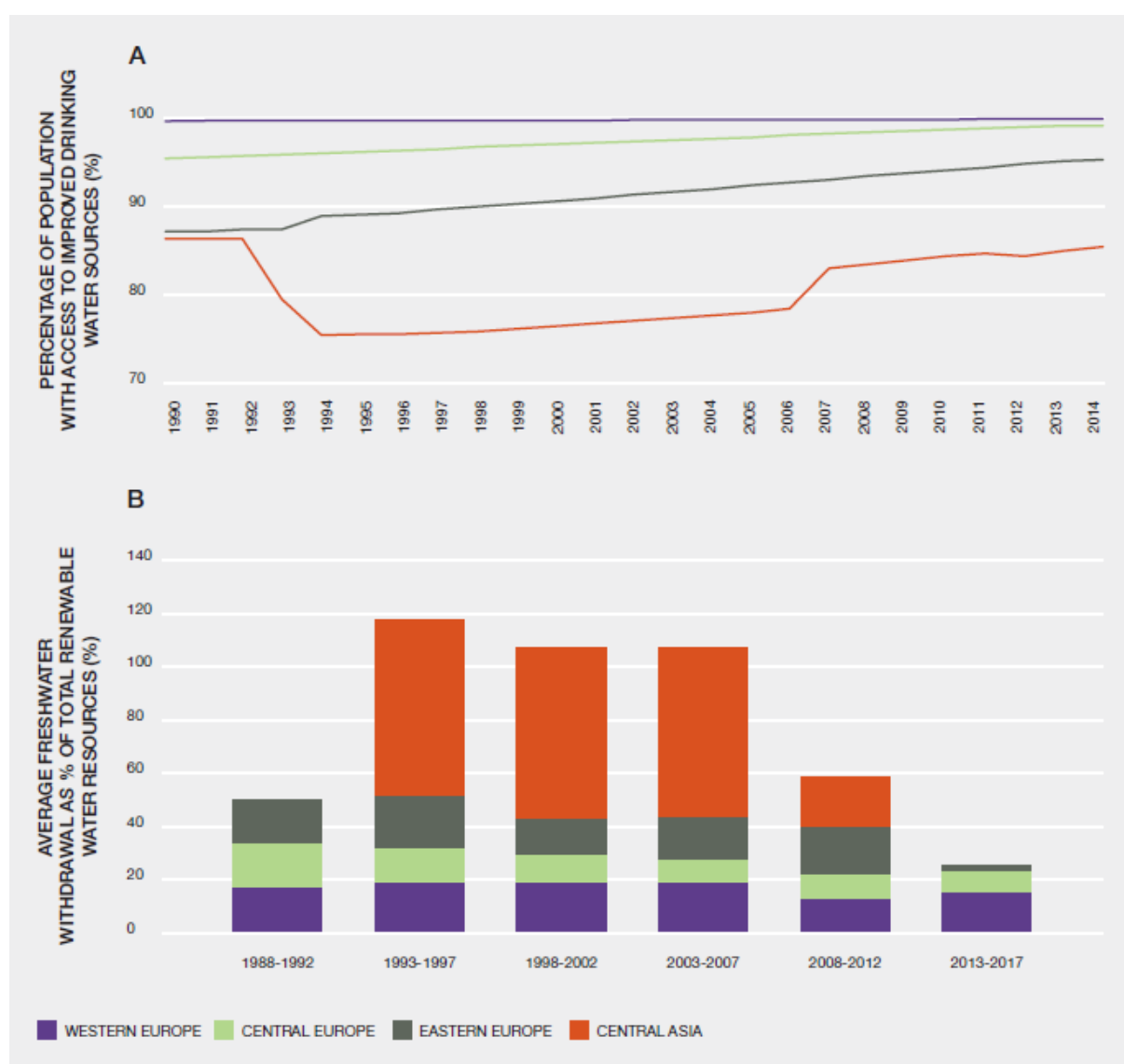


Figure 2.62: Temporal trends in water security in Europe and Central Asia according to (A) access to safe drinking water. Own representation based on: World Bank (2016) and (B) freshwater withdrawal as percentage of total renewable water resources. Own representation based on: (FAO, 2016). Note that information for 2013-2017 is incomplete.

Water security in Western Europe and Central Europe has remained stable since the late 1980s, despite a 40% and 5% decrease, respectively, in per capita freshwater availability since the 1960s (see Section 2.2.1.5) and a slight increase in water quality but on-going decrease in water quality regulation (see Section 2.2.1.6). Water security in Eastern Europe shows mixed but generally increasing trends since the late 1980s, while per capita freshwater availability has increased by 10% since the 1990s. Several Danube river sub-basins in Eastern Europe were highlighted as being at risk of becoming waterscarce (Karabulut et al., 2016).

Central Asia is considered to be facing water scarcity and shows mixed trends since the early 1990s (Animesh et al., 2016; UNEP/UNECE, 2016). Access to safe drinking water has increased since 1994-2007, while recent trends for freshwater extraction as a percentage of available water are mixed and even decreasing (Alexander & West, 2011). This coincides with a mixed, but recent decrease in per capita freshwater availability since the 1990s (see Section 2.2.1.5). Ensuring water security in Central Asia depends on the distribution of, and access to, water resources, especially between different

countries (Abdolvand et al., 2014; Conrad et al., 2016; FLERMONECA, 2015).

2.3.1.4 Food-energy-water security nexus

Water, food and energy systems are characterized by complex interrelations. Energy is required to process and distribute water; water is central to nearly all forms of energy production; and both energy and water are key to any food enterprise (Harvey & Pilgrim, 2011; Hussey & Pittock, 2012; Karabulut et al., 2016). Pursuing one particular security objective (either food or water or energy security) is sometimes achieved to the detriment of another, reflecting competing claims over limited natural resources and nature's contributions to people.

Agriculture intensification in Europe and Central Asia since the early 1950s has contributed significantly to an increase in the provision of food and feed (see Section 2.2.2.1) and to enhancing food security (see Section 2.3.1.1). However, it has had severe adverse effects on water security in many parts of the region (see the example of the Aral Sea in **Box 2.3**). Intensive agriculture has been one of the main causes of the pollution (eutrophication and contamination) and overexploitation of freshwater bodies and the decrease in the extent of floodplains and wetlands (UNEP/UNECE, 2016). These trends have impaired water quality and quantity regulation (see Sections 2.2.1.6 and 2.2.1.7). In addition, many of nature's other regulating contributions to people, especially pollination, erosion, soil formation and functioning, regulation of flood control; and non-material contributions, such as traditional farming knowledge, have been negatively impacted by agriculture intensification. Another major trade-off associated with agricultural intensification concerns climate. Intensive agriculture is characterized by a loss of carbon in agricultural soil, which impairs its climate regulation capacity and other contributions from nature to people associated with soil (see Section 2.2.1.4 and Section 2.2.1.8). It also entails increasing emissions of fossil carbon used for mechanization and fertilizer production, and of greenhouse gases from cattle and nitrogenous fertilizers (see Section 2.2.1.3 and Section 2.2.1.4). However, over the last 25 years, agricultural intensification has triggered the abandonment, reforestation and afforestation of former agricultural land, especially in Western Europe (see Chapter 4). An increase in forest areas was the main cause of a net increase in greenhouse gas storage in ecosystems in Western, Eastern and Central Europe between 1990 and 2012 (see Section 2.2.1.4).

Biofuels also pose major potential trade-offs between security objectives. Over the past 15 years, the European Union policy for renewable energy and its biofuels blending target for transportation fuel (set at 10% by 2020 in the European Union Renewable Energy Directive (2009/28/EC)), have fostered the production and consumption of biofuel in Western and Central Europe (Sections 2.2.2.2 and 2.3.1.2). Biofuel production carries the risk of competing with food production, increasing food prices, intensifying agricultural land and water use, and harming biodiversity and other contributions from nature to people (De Fraiture et al., 2008; Gerbens-Leenes et al., 2012; Rulli et al., 2013; Rulli et al., 2016). Moreover, the potential of biofuels to reduce greenhouse gas emissions may be offset by the contribution of their production to emissions arising from fertilizers, machinery, and especially land conversion. Projected change in cropland area within the EU-28 caused by compliance with the 10% blending target mainly takes the form of less land abandonment (Valin et al., 2015). Nevertheless, the adverse effects of biofuels vary spatially and depend on the choice of biofuel crop (de Vries et al., 2010; Eggers et al., 2009; Valin et al., 2015). Biofuel derived from properly managed feedstocks with much lower life cycle greenhouse gas emissions than fossil fuels, and which do not compete with food production (mainly biofuel produced from ligno-cellulosic materials), do not entail negative impacts on land and water use, biodiversity, or greenhouse gas emissions (Havlík et al., 2011; Tilman et al., 2009). However, biofuel production in north-western Europe is currently mainly produced from wheat

and maize (for bioethanol), and sugar beet and rapeseed (for biodiesel), which perform rather poorly for nearly all environmental indicators, as well as for greenhouse gas emissions (de Vries et al., 2010). Moreover, the European Union 2020 biofuel mandate impacts ecosystems, water and food security globally through European Union imports. In the scenarios developed by Valin et al. (2015), most of the land use change resulting from the European Union 10% blending target occurs outside the EU-28, especially through conversion to oil palm in Southeast Asia.

Box 2.3: The Aral Sea disaster

The Aral Sea provides clear evidence of how the pursuit of one security objective can be to the detriment of others. During the Soviet era, pressure on the water resource in the Aral Sea region was mainly due to the massive development of irrigation for rice and cotton production. After the dissolution of the Soviet Union, cotton production was reduced but remained key for generating currency revenues. Besides, irrigated winter wheat production grew rapidly to gain grain self-sufficiency (Jalilov et al., 2016). In Central Asia as a whole, the areas under irrigation increased from 4.51 million ha in 1960 to 6.92 million ha in 1980, and to 7.85 million ha in 2000 (Rakhmatullaev et al., 2010). Irrigation systems in the region are highly inefficient with almost half of the water diverted for irrigation lost before reaching the field. Over 50% of the irrigated soils of the region are salinized and waterlogged, due to long-term surface irrigation practices (Qi et al., 2012). Changes in the hydrological cycle caused by the massive irrigation led to a significant decrease of river runoff, changes in the area of lakes, and rise of groundwater levels. Hydrological changes, including desiccation of the Aral Sea, basin-wide land-use and land-cover changes, as well as the degradation of the Aral Sea have strongly contributed to climate change in the region (Lioubimtseva, 2015; Micklin, 2007). Dust storms, with dust contaminated by fertilizers, pesticides, heavy metals, and other chemicals; water and wind erosion; widespread land degradation; water pollution; and frequent droughts have negatively impacted populations' health (Jensena et al., 1997; Wiggs et al, 2003), agricultural productivity and economic development in the area (Cai, McKinney, & Rosegrant, 2003; Lioubimtseva, 2015). In Central Asia as a whole, access to improved drinking water declined from 57 % in 1990 to 50 % in 2013 (Abdullaev & Rakhmatullaev, 2016). Cai and co-authors (2003) estimate that thirty-five million people have lost access to the lake's water, fish, reed beds, and transport functions.

End of Box 2.3

2.3.2 Contributions to physical, mental and social dimensions of health

The recent state of knowledge review coordinated by the World Health Organization and the Convention on Biological Diversity (WHO & CBD, 2015) provides a detailed global assessment of the interlinkages between biodiversity and human health. The review explores the evidence base across three broad areas of human health outcomes – non-communicable diseases, communicable (i.e. infectious) diseases, and injury – and considers the value of biodiversity to medical science (WHO & CBD, 2015). The role of biodiversity and ecosystem services in supporting human health, and the health risks arising as a result of loss of biodiversity and ecosystem degradation are also highlighted by the review.

The linkages between nature and health are of increasing research and policy interest. While research efforts are increasingly interdisciplinary, there is still a need for greater integration of different fields of expertise and recognition of the importance of accounting for different forms of knowledge, as with other aspects of biodiversity policy (Pullin et al., 2016). With this perspective in mind, in addition to following the literature review methodology of this chapter we also engaged in a process of IPBES-approved expert elicitation to strengthen the quality of the assessment and literature review. This also supports a key aim of IPBES, which is to build capacity in this rapidly growing field. The expert elicitation was based on the consideration of the World Health Organization and Convention on

Biological Diversity literature review and key messages by an expert panel. Further details are provided in the electronic Appendix 2.8.

The importance of biodiversity and ecosystem services to human health is well established in some areas of health research, for example with regards to the contribution of biodiversity to contemporary and traditional medicine (Heinrichs & Jäger, 2015; Payyappallimana & Subramanian, 2015), to food and nutrition security (Hillel & Rosenzweig, 2008; Hodgkin-Hunter, 2015), and through linkages to infectious disease risk (Karesh & Formenty, 2015). Traditional medicinal practice has long been based on preparations derived from wild or domesticated species, and the value of biodiversity is recognized in contemporary medicinal research, with the development of new pharmaceuticals supported by bioprospecting and often based on lessons from traditional knowledge (Newman & Cragg, 2016). The evidence regarding the contribution of biodiversity to food and nutrition security is also well established. Globally, diets rich in biodiversity (cultivated varieties as well as wild sources such as fish, fruit, fungi, invertebrates and bushmeat) help to support good nutrition, with many communities relying heavily on wild biodiversity as a primary source of energy, protein and micronutrients; for Europe and Central Asia data are limited, but some work has highlighted the cultural and economic significance of wild foods (Fuchs et al., 2016; Łuczaj et al., 2012; Schulp et al., 2014b). Schulp et al., (2014b) identified 38 species of game, 27 species of mushrooms, and 81 species of vascular plants that are regularly hunted, collected and consumed in the European Union, with over 100 million European Union citizens consuming wild food each year, and argue for greater attention to be given to wild foods in ecosystem service assessments. There is evidence that dietary diversity may help to reduce the risks associated with certain non-communicable diseases, though this is moderated by effects of lifestyle and other socio-economic factors (Hunter-Burlingame-Remans, 2015; Johnston et al., 2014).

Ecosystem change and degradation of natural habitats are identified as risk factors for disease emergence, though the precise contribution of biodiversity, or its loss, to risk of infectious disease outbreaks in wildlife, livestock or humans is generally less certain (Ostfeld & Keesing, 2012; Wood et al., 2017). Biodiversity may reduce disease risk through a phenomenon known as the “dilution effect”, whereby, in ecosystems where hosts of an infectious agent vary in their ability to transmit an infection, increased diversity of potential hosts may reduce the risk of disease outbreak. This concept remains controversial, and any such effect is likely to be highly specific to pathogen, location or geographic scale (e.g. (Randolph & Dobson, 2012; Wood & Lafferty, 2013). Some evidence for the dilution effect in at least some local contexts has been presented from several studies, mostly from Western Europe (e.g. Bolzoni et al. (2012); Kedem et al. (2014); Khalil (2016); Ruyts et al. (2016)).

Another area where the relationship between biodiversity and ecosystems and health may be highly variable is the impact which exposure to nature can have on mental and physical wellbeing (Horwitz & Kretsch, 2015; Lee & Maheswaran, 2011; Van Den Berg et al., 2015). The ways in which health is affected by biodiversity and nature’s contributions to people is determined by the nature of specific social-ecological systems, including the degree and types of interactions between people or their communities and the natural environment. This highlights the importance of social, economic and cultural factors in determining the strength and direction of linkages between health and biodiversity (Clark et al., 2014; WHO, 2017; European Commission, 2016c).

Increased urbanization in Europe and Central Asia poses significant challenges for human health including a rise in non-communicable diseases associated with modern lifestyles, including obesity and diabetes, cardiovascular diseases, depression and anxiety disorders, and diseases associated with pollution (Benziger et al., 2016). Efforts to increase access of urban dwellers to green space and open countryside may help to address some of these health issues. Scientific review literature shows there are many potential pathways between exposure to nature or natural spaces and positive health status.

However, these pathways do not necessarily exist for all persons within any given community, even where different social groups (differentiated by, for example, age, gender, ethnicity, income level, or education) have access to, or utilize, common areas of natural space (Hartig et al., 2014; Jackson et al., 2013; Myers & Patz, 2009). Again, several social, cultural and economic factors are likely to be at play, and more research is needed in this regard (Clark et al., 2014).

Differentials in the ways in which some communities or groups within wider society (e.g., indigenous groups, refugees, women, the elderly or poor) experience and interact with biodiversity and ecosystems may result in differences in the influence of biodiversity and ecosystems on their health status. There is, thus, potential for group-specific or community-specific dependencies and risks (WHO, 2017; Horwitz & Kretsch C., 2015; Jay et al., 2012). Individual groups within a community (defined by, for example, gender, age, ethnicity, infirmity, engagement in cultural practices) may experience greater or lesser health benefits from biodiversity and ecosystem services, or be at greater or lesser risk of ill health associated with biodiversity loss and ecosystem change, than others, as a result of a range of moderating social, economic and cultural factors. Any relationships which can be drawn between health outcomes and biodiversity or ecosystem services are, therefore, likely to be dependent upon the ways in which groups or individuals understand, acknowledge or experience their relationship with the natural environment (Clark et al., 2014).

There is well established evidence from multiple studies that a healthy immune system is supported by exposure to biodiversity (Rook & Knight, 2015). Exposure to environmental microbiota has been associated with reduced risks of allergy, chronic inflammation and certain other autoimmune diseases. A growing body of evidence suggests that interactions between wild microbes and the human microbiome - the diverse community of microbes present in the intestinal, respiratory and urogenital tracts, and on our skin – may be key to healthy immune function. Conversely, loss of diversity in human microbiota, which may be associated with decreased exposure to wild microbes, has been linked to increased risk of a range of non-communicable diseases, including inflammatory diseases, diabetes and allergies (Hanski et al., 2012; Ruokolainen et al., 2017).

With so many significant linkages identified between health and biodiversity, and with increased knowledge of the health risks posed by ecosystem change and biodiversity loss, numerous opportunities exist for development of integrated policies and practical strategies to realize benefits for both biodiversity and human health and well-being. Biodiversity conservation provides opportunities to secure and enhance those ecosystems and ecosystem services that are of particular relevance to human health outcomes (Romagosa et al., 2015; ten Brink et al., 2016). A review of national reports to the Convention on Biological Diversity (see electronic Appendix 2.8) examined the extent to which countries in Europe and Central Asia consider nature–human health linkages. Almost all countries involved in the analysis (covering 93% of those in the region) explicitly recognized the importance of nature–human health linkages. Only 8% mentioned these linkages in general terms, while the majority considered key details such as the diversity of linkages, local specificities, challenges, opportunities and actions. Some countries also mentioned local practice examples regarding application of health-relevant insights. Most (63%) mentioned both human health benefits and risks of nature-human linkages, while 6% mentioned only risks and 27.5% only benefits.

2.3.3 Cultural heritage, identity and stewardship

2.3.3.1 Value through use

For different social groups in Europe and Central Asia, nature contributes to cultural heritage, identity and stewardship through providing opportunities for good quality of life beyond mere survival. It offers

opportunities for leisure and tourism, maintaining indigenous and local knowledge, and being exposed to learning, inspiration and spiritual experiences. Evidence suggests that these contributions from nature to people show increasing trends (see Section 2.2.3).

Nature is in high demand for nature-based recreation activities by people in many parts of the region (see Section 2.2.3.2.1) (Hausner et al., 2014; Martin-Lopez et al., 2012; Rall et al., 2017) and preferences for holidays of people in the European Union in the last decade, show an increasing interest in nature-based tourism (European Commission, 2016b). In addition, the number of visitors to protected areas increased between 1995 and 2009 in some Western European countries, such as Spain, Finland and the UK (Figure 2.63).

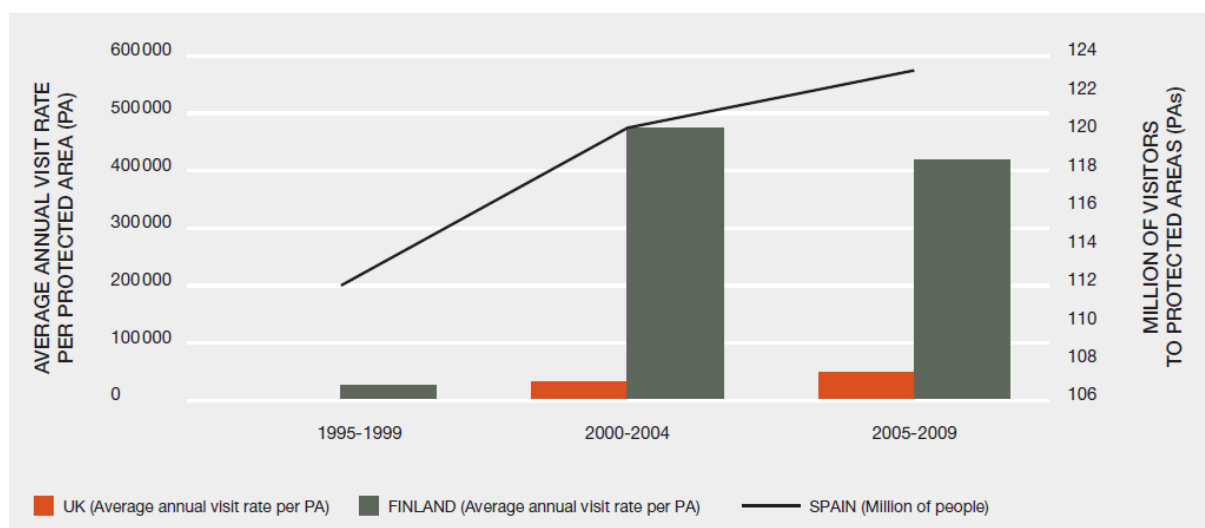


Figure 2.63: Number of visitors to protected areas in the United Kingdom and Finland (measured as average annual visit rate per protected area) and Spain (measured as millions of visitors) (Own representation based on: Balmford et al. (2015); Santos-Martín et al. (2013)).

Recreation and leisure are recognized by urban people as the most important benefits derived from urban green spaces. Other motivations to visit urban greenspaces include health, psychological wellbeing and emotional attachment to the site (Bolund & Hunhammar, 1999; Casado-Arzuaga et al., 2013; Haase et al., 2012). Green spaces and ecosystems are also used for formal learning by schools and universities in many countries in Europe and Central Asia, where outdoor learning provides additional value for learners and teachers in terms of knowledge and skill acquisition (Mocior & Kruse, 2016).

Indigenous and local knowledge has significant value for some local communities in Europe and Central Asia. A review of studies in Arctic regions argues that this knowledge plays an important role in land rights claims (Davis & Wagner, 2003). An in-depth study of resource-users and local organizations involved in a local fishery in Sweden shows how indigenous and local knowledge can contribute to fish management and conservation (Olsson & Folke, 2001). Co-production of knowledge by traditional herders and national park rangers for adaptive nature conservation management of wood-pastures and salt steppes can also lead to new occupations, like the so-called “conservation herders” (Molnár et al. 2016). Furthermore, the conservation of indigenous and local knowledge and related landscapes can support the economic development of rural areas by fostering tourism and consumption of local products, and contributing to the quality of life of people (Fernández-Giménez & Fillat Estaque, 2012; Parrotta & Agnoletti, 2007).

However, in many areas of Europe and Central Asia the value of local ecological knowledge has been eroded with a decline in indigenous and local knowledge. Studies comparing the UK to developing

countries have argued that indigenous and local knowledge declines as nations become wealthier and ecological knowledge becomes less valued (Pilgrim et al., 2008). Changes in culture are partly responsible for the devaluation of indigenous and local knowledge among younger generations, which consider these traditional practices and knowledge as symbols of poverty or backwardness.

The use of some of nature's material contributions to people is also strongly connected to values arising from non-material contributions, which contribute to cultural practices that enhance identity (see Sections 2.2.3.2 and 2.2.3.3). For example, in many Central and Western European countries, mushroom collecting is a part of culture and tradition (Hansen & Malmaeus, 2016; Martínez de Aragón et al., 2011; Stoyneva-Gärtner, 2015). Recreational berry picking is also often a family and cultural tradition, which has been kept alive during recent decades (Schulp et al., 2014b), mostly in Scandinavian countries (Kangas & Markkanen, 2001). It has been estimated that 56-58% of households in Scandinavian countries collect berries for domestic purposes (Jonsson et al., 2002).

Belief systems are a fundamental aspect of people's culture that strongly influence their engagement with nature (Groot et al., 2005). Religious or spiritual interactions with nature have been shaped over decades or centuries, and influence human endeavour directly or indirectly (IPBES Values Guide 2015). Many traditional knowledge systems in Europe and Central Asia depict ecosystems as fully alive, incorporating spirits of animals and other natural objects and spirits of human ancestors (Berkes et al., 1998). Pre-monotheistic belief systems integrated elements of nature to give meaning to the world and humans' place in it (Verschuuren, 2006). Similarly, myths and related rites have existed in Europe and Central Asia since the dawn of humanity (see **Box 2.4**). For a number of local and indigenous communities in Europe and Central Asia, especially those that have pagan, animistic or shamanistic roots, land is alive and full of various kinds of energies or life forces and nature's organizing principles are depicted as entities, spirits or natural law (UNEP, 1999).

Box 2.4: The Cult of Hızır as an Expression of Revering Nature's cycles

Seasonal changes are important components of folk calendars throughout the world. In the Turkic world (including Yakuts, Mongols, Kalmyks, Buryats and Tungusic people in Central Asia), Hidrellez (known as Ruz-ı Hızır or day of Hızır) is one of the most important seasonal celebrations and represents the revival of the warm and productive summer days (Uca, 2007). Based on folk calendar traditions, the year is divided into two, the summer known as "Days of Hızır" and the winter, known as "Days of Kasım". Hidrellez Day falls on May 6 and is the day on which Prophets Hızır and İlyas met on the seashore between dry land and water (Artun, 1990).

The awakening of nature is actively celebrated throughout the Turkic world on Hidrellez day with rites that are dependent on water (Walker, W.S. and Uysal, 1973). These ceremonies generally take place in nature, near sources of water, or near tombs and shrines. In rituals before sunrise on that day, Turks construct, in their gardens, models of the things they wish for most such as good health, or write their wishes on pieces of paper which are then either released into rivers and other water bodies or hung on trees (Walker, W.S. and Uysal, 1973).



5185

5186 *Tahtacı* Turkmen villagers in the northern Aegean Kaz Mountains line up to wash their face in the early morning
 5187 of Hidrellez to receive health and bounty from the river waters.

5188 Photo Credit: Solmaz Karabaşa

5189 **End of Box 2.4**

5190

5191 *2.3.3.2 Value through protection and beyond use*

5192 Different social groups indicate the value of their relationship with nature by expressing their desire to
 5193 conserve and protect areas and iconic species that they do not use directly. People can express this
 5194 form of value through willingness-to-pay and indications of other preferences for the protection of
 5195 species irrespective of actual aesthetic or recreational use (see Section 2.2.3.4).

5196 Protected areas are increasingly valued for their use and recreation potential. European Union people
 5197 increasingly acknowledge their importance for eco-tourism and nature-related recreational
 5198 experiences and 43% of European Union citizens identified this role of protected areas as very
 5199 important (European Commission, 2015b). In addition, visitors to protected areas and UNESCO World
 5200 Cultural Heritage Sites around Western and Central Europe have expressed substantial willingness to
 5201 pay to enjoy the recreational services provided (Martin-Lopez et al., 2009;), including in Turkey (Gürlük
 5202 & Rehber, 2008) and Albania (Seidl, 2014).

5203 A further value of tangible and intangible protected heritage associated with nature is that it helps to
 5204 maintain cultural meanings and a sense of identity (Klinar & Geršič, 2014; Tengberg et al., 2012). This
 5205 can be based on the tangible material outcomes of cultural activities on landscapes (e.g., wood
 5206 pastures, viticulture terraces) as well as individual species that are linked to intangible heritage such
 5207 as through myths, legends, and religious practices (Daniel et al., 2012).

The value placed on the protection of tangible heritage linked to nature is shown in UNESCO’s World Heritage List in 2015, comprising 1,031 properties of which 22% were natural sites (Osipova et al., 2014). Currently, 23.5% of these protected natural sites are located in Europe and Central Asia, with an unequal distribution among subregions (see **Figure 2.64**). Tangible heritage linked to cultural landscapes in Western, Central and Eastern Europe is also recognized in UNESCO’s “list of cultural landscapes” (Besio, 2003). 51% of the landscapes in the UNESCO list (i.e. 49 landscapes) are situated in Europe and Central Asia, but again with uneven distribution among subregions (see **Figure 2.65**).

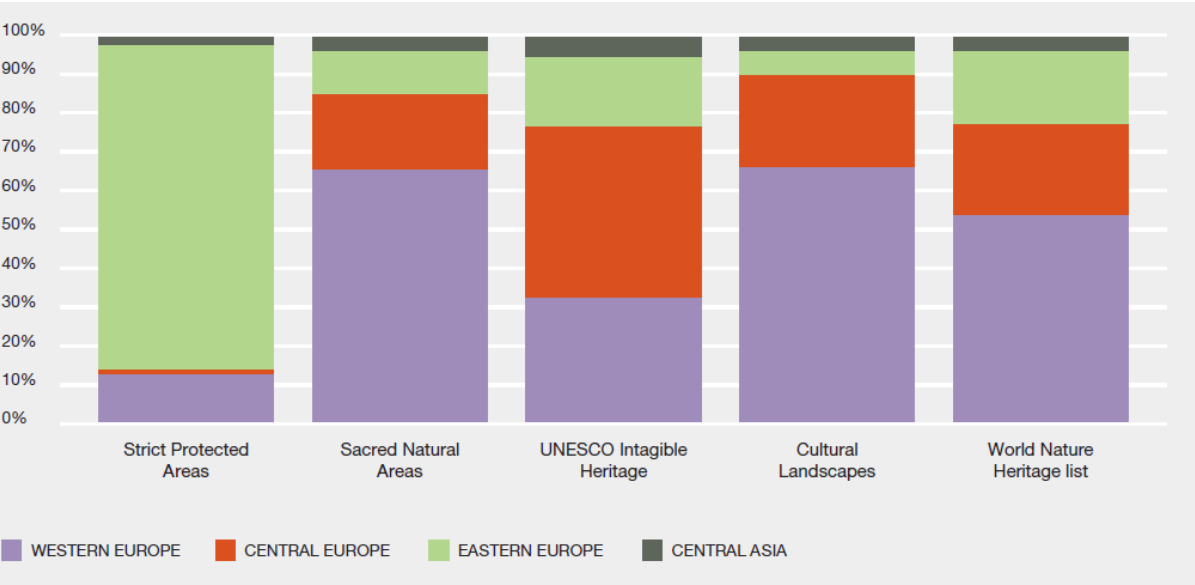


Figure 2.64: Distribution of the different types of protected areas among Europe and Central Asia subregions.

Yet, tangible heritage linked to European cultural landscapes is increasingly threatened by land-use intensification and abandonment (Tieskens et al., 2017) that derive from cultural, political and economic drivers of change (see Chapter 4) (Plieninger et al., 2016). The decreasing trends of the cultural and local identity associated with these landscapes, as well as the emotional attachment of Western and Central European people to these landscapes, is also acknowledged by indigenous and local knowledge holders (electronic Appendix 2.2).

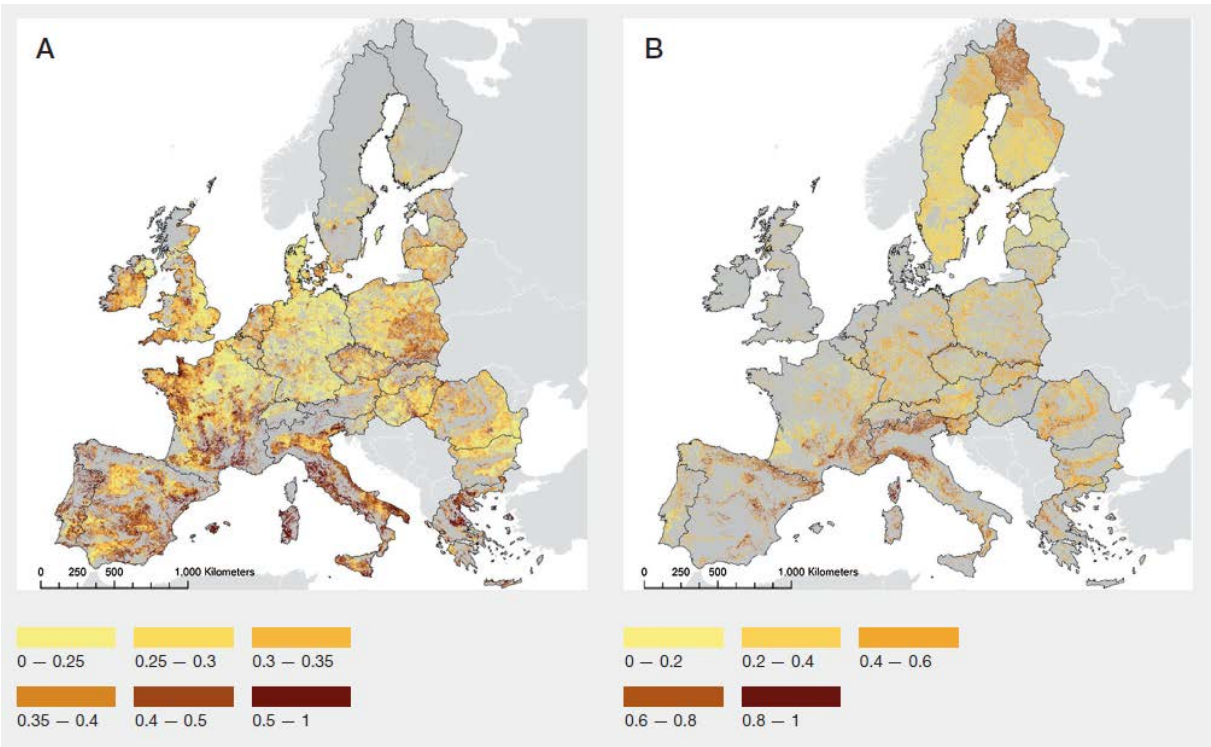


Figure 2.65: Cultural Landscape Index (CLI) of Western and Central European (A) agricultural land and (B) forest that characterizes rural landscapes according to landscape structure, management intensity, and value and meaning. Source: Tieskens et al. (2017).

The *Convention for the Safeguarding of the Intangible Cultural Heritage* is the international agreement that aims to acknowledge and protect intangible heritage. Out of 130 elements of intangible heritage from countries in Europe and Central Asia currently inscribed on the List of Intangible Cultural Heritage (UNESCO, 2003), 53 are directly linked to nature. They are linked to both the direct use of animals (e.g. falconry, and horse-riding games) and plants, or draw on the natural environment as a source of inspiration for songs, poetry and handicrafts.

Despite the value and protection of intangible and tangible heritage linked to nature, it continues to be threatened. In Western, Central and Eastern Europe, 30% of natural World Heritage sites are of significant concern (Osipova et al., 2014) and five protected sacred natural sites in Europe and Central Asia are threatened (one in Central Europe, one in Eastern Europe, two in Western Europe and one in Central Asia).

2.3.4 Environmental equity and justice

2.3.4.1 Framing equity and justice

Aspects of equity and justice associated with nature’s contributions to people relate to questions of who benefits from them (Daw et al., 2011; McDermott et al., 2013), who bears the costs of a change in the provision of these contributions due to trade-offs (Bennett et al., 2009; Howe et al., 2014), who decides how societies influence the provision of the contributions (Berbés-Blázquez et al., 2016), who is recognized in these decisions (Martin et al., 2016; Zafra-Calvo et al., 2017) and whose needs are fulfilled by nature’s contributions to people (Chan et al., 2012; Jax et al., 2013). Equity is associated with fairness and justice (Konow, 2003; McDermott et al., 2013; Pascual et al., 2010). *Fairness* is often defined as the shared, dynamically constructed view of a given social group of distributive justice (Unai

Pascual et al., 2010; Schokkaert & Devooght, 2003). The term *justice* refers here to fundamental moral rights and obligations. The term *equity* is used to evaluate comparatively the relationships between particular groups in society.

Distributive equity and justice focuses on the fair allocation, among individuals within a social group or among stakeholders, of costs (see **Box 2.5**) and benefits resulting from any management decision or action (McDermott et al., 2013). *Procedural equity and justice*, in the context of the present assessment, relates to the procedural aspects of decisions on ecosystem management. It is assessed in terms of the degree of recognition, representation, involvement and inclusiveness in decision-making of different societal groups, determined e.g. by cultural identities, level of education and gender (Berbés-Blázquez et al., 2016; McDermott et al., 2013; Pascual et al., 2010; Pascual et al., 2014). Distributive justice and equity regarding the benefits derived from nature's contributions to people and harms from a loss of these contributions have a spatial component, as changes in ecosystems providing them will have uneven geographical impacts linked to where beneficiaries live (Liu et al., 2016), see Section 2.1.2. There is also a temporal component (Jax et al., 2013) as ecosystem service utilization today may destroy the basis for future service provision (Section 2.2.3.4).

2.3.4.2 Intra-generational distributive equity and justice

Nature's material contributions to people are often commodities traded in (global) markets. On the one hand, distributional equity and justice reflects the distribution of access to markets (UNEP, 2004). On the other hand, distributive equity and justice are influenced by global patterns in the distribution of benefits and costs from the production and consumption of nature's material contributions (such as biofuels, soy for animal feed, timber, pharmaceutical products from wild and domesticated biodiversity) (Section 2.2.4).

Whereas access to safe and adequate drinking water is generally well secured in Europe, people in Central Asia, especially children, bear disproportionate environmental threats to their health due to a lack of access to safe drinking water – with the Aral Sea region and rural areas in Tajikistan being specific problem areas (see Section 2.3.1.3) (Carpenter et al., 2006).

Urban green space can provide different regulating contributions such as prevention of urban heat islands, air quality regulation and noise reduction (Konijnendijk et al., 2013). Its distribution has been shown to differ across a city resulting in lower access in residential areas with specific ethnic groups (Comber et al., 2008) or a high proportion of immigrants (Kabisch & Haase, 2014).

Regarding flood regulation and flood protection measures (Section 2.2.1.6), a socio-economic investigation within the flood plains of England and Wales revealed significant inequalities in the distribution of flooding risk between the middle classes and less privileged groups (working classes, unemployed classes) – with inequality being especially influential in exposure to flooding risk within the tidal flood plains and in the Eastern regions of England (Benzie, 2014; Fielding, 2007, 2012; Walker & Burningham, 2011).

Nature's non-material contributions to people, in particular recreation, can be distributed unevenly across social groups. In the UK protected areas are largely enjoyed by older people and men, while minorities are underrepresented in the use of protected areas, and hence the more privileged people benefit (Booth et al., 2010). Access to green space in cities provides opportunities for recreational experiences, but urban green space is distributed unequally within cities, leading to potential injustice (Comber et al., 2008; Kabisch & Haase, 2014). Access to green space in cities differs across Europe, with more green space available to residents in cities in northern, western and central parts of the European Union than in cities in the south (Kabisch et al., 2016). Access to green recreational areas

reduced inequality in mental wellbeing in the Europe Union (Mitchell et al., 2015). In Europe and Central Asia national reports to the Convention on Biological Diversity, several countries mention how health equality is influenced by human interactions with nature's contributions and biodiversity see electronic Appendix 2.8).

In several countries in Europe and Central Asia, people have public access to forests that provide recreational experiences, but the uneven distribution of access raises justice issues. A high level (98-100%) of forests and wooded land were reported in 2010 as available for recreational purposes in Nordic and some Baltic countries as well as in several Central Europe countries including Bosnia and Herzegovina, Slovenia and Serbia. Lower levels of availability are found in some Western European countries such as UK (46%) and France (25%) (Forest Europe, 2015). The free use of some non-timber forest products is mostly allowed in Nordic countries as well as some other countries with high forest cover, and allowed to some extent in other countries. In some cases permission or payment is required (e.g. private forests in Croatia, France, UK, Turkey) (Bauer et al., 2004).

Box 2.5: Human-wildlife conflicts (additional references can be found in electronic Appendix 2.3)

Certain species cause human-wildlife conflicts and raise justice concerns in terms of the distribution of their damages (Jacobsen & Linnell, 2016). Human-wildlife conflicts in Europe and Central Asia are reported related to carnivores, mainly wolves (*Canis lupus*), brown bears (*Ursus arctos*) and European lynxes (*Lynx lynx*) (e.g. (Imbert et al., 2016; Knarrum et al., 2006; Mattisson et al., 2015; Rigg et al., 2011)), although conflicts with meso-carnivores (e.g. European badgers (*Meles meles*) and red foxes (*Vulpes vulpes*)) are also reported in Western Europe (Baker et al., 2008; Delibes-Mateos et al., 2013). The most frequent conflicts in Eastern, Central and Western Europe (no available data for Central Asia) are those related with damage to livestock and domestic animals (Kovářík et al., 2014), damage to game species (Lozano et al., 2013) and attacks on humans (Sahlén et al., 2015). Other mammal species, such as moose (*Alces alces*) and wild boars (*Sus scrofa*), cause damage to agriculture and forest plantations (Horne & Petäjistö, 2003; Schley et al., 2008). Many alien insect and mite species cause nuisances as pests of agriculture, horticulture, stored products and forestry (Kenis & Branco, 2010; Roques et al., 2009).

End of Box 2.5

2.3.4.3 Intergenerational distributive equity and justice

Intergenerational equity and justice require the maintenance of resilient and productive ecosystems for the future provision of nature's contributions to people (Davidson, 2012; Glotzbach & Baumgärtner, 2012; Jax et al., 2013). This capacity of ecosystems, "maintenance of options", is considered an overarching contribution category. Regarding intergenerational equity there are philosophical and practical arguments for an absolute sufficientarian threshold (Page, 2007), which defines a minimum level of ecosystem services that every future person is presumed to need for good quality of life. Regarding intergenerational equity in the distribution of beneficial contributions from nature to people, the sufficientarian threshold can be translated into a criterion for society to keep a constant stock of intact ecosystems (Ekins et al., 2003) and a dynamic criterion of ecosystem resilience. The first criterion has been operationalized by general principles of sustainability (Daly, 1992) and specified principles, such as sufficiency, efficiency and persistence for the context of nature's contributions to people (Schröter et al., 2017). The ecosystem resilience criterion captures the reliability of future provision of (life-sustaining) contributions. It has been operationalized into policy-relevant principles for enhancing the resilience of desired contributions, such as maintaining biodiversity and redundancy (Biggs et al., 2012) and into the concept of safe operating space in the global context (Rockström et al., 2009; Steffen et al., 2015). An example of putting intergenerational equity into policy practice is the Swedish *generational goal* which was adopted by the Swedish

Parliament in 2010 (MEF, 2014). The goal is to pass on to the next generation a society in which the major environmental problems have been solved, ensuring that ecosystems recover, biodiversity and the natural and cultural environment are preserved, promoted and used sustainably.

2.3.4.4 Procedural equity and justice

Distributive justice regarding nature's contributions to people and biodiversity is linked to historical injustices, i.e. historically determined unequitable distribution of property rights on which access rights to nature's contributions are frequently based (Berbés-Blázquez et al., 2016). Historically, certain societal groups have been absent from decision-making arenas. Indigenous and local knowledge holders, such as farmers, indigenous communities, elders and women, are frequently among those whose participation is not sought or whose perceptions of nature-society relationships might differ from those who formulate and implement policy. This "procedural inequity" can result in trade-offs between nature's contributions to people that contribute to the wellbeing of some at the expense of others' (e.g. Daw et al. (2015)). The fact that certain social agents such as indigenous and local knowledge holders are not represented in decision-making can entail distributional inequity in the access and use of nature's contributions to people (Felipe-Lucia et al., 2015) and can result in social conflicts (Kovács et al., 2015).

The Aarhus convention on access to environmental information promotes public participation in decision-making and access to justice in environmental matters, which can be supportive to procedural empowerment granted to NGOs (De Santo, 2011). There are, however, large differences in terms of access to information and participation in decision-making, both nationally and regionally, with Western Europe being the most advanced (Mauerhofer, 2016). A UK case study shows the importance of early stakeholder participation: planning proposals not involving stakeholders at an early stage came to a halt and had to be changed due to stakeholder objections (Lange & Hehl-Lange, 2011).

Procedural justice is also influenced by levels of empowerment defined as "enhancing an individual's or group's capacity to make effective choices, effective in the sense of enabling them to transform those choices into desired actions and outcomes" (Alsop & Heinsohn, 2005). Key elements of empowerment are personal agency (the capacity to make meaningful choices) and opportunity structure (the formal and informal institutional contexts within which actors operate). Ecosystem management approaches have been shown to contribute to the empowerment of marginalized groups through increased knowledge and gaining a political voice (Charron, 2012). Deer management in Scotland through collaborative governance has the potential to help reconcile statutory obligations with stakeholder empowerment (Davies & White, 2012). In Poland the institutional context of urban greening has led to social empowerment failures: society perceives other issues as more pressing, trees are perceived as a problem, and there is a lack of knowledge on the possibilities of preventing tree damage (Kronenberg, 2015).

2.3.5 Valuing nature's contributions to people

The importance of nature's contributions to people can be measured from different value framings, including economic and socio-cultural value domains (Martín-López et al., 2014; Pascual et al., 2017). A range of valuation tools can be used to elicit the different aspects of the value of nature's contributions to people (Jacobs et al., 2017). Economic approaches are capable of eliciting the monetary value of these contributions through market-based approaches (e.g. market pricing) and non-market approaches (e.g. travel cost method, hedonic pricing or stated preference methods).

Other approaches avoid using monetary calculations and instead elicit both instrumental and relational values in socio-cultural metrics (e.g. preference assessment, narratives or time use method) (Jacobs et al., 2017). While economic valuation is often framed in the so-called “total economic value” framework that captures use and non-use values (Pearce & Moran, 1994), social dominated valuation examines the importance, preferences or needs expressed by people towards nature (Chan et al., 2012). IPBES adheres to value pluralism recognizing the multiple and often conflicting valuation languages to show the multiple ways nature contributes to human wellbeing (Gómez-Baggethun & Martín-López, 2015; IPBES 2016a). Below, we provide a synthesis of the plurality of values of nature’s contributions to people across Europe and Central Asia by reviewing value evidence published over the last decade. In doing so, we advocate a value assessment framework that extends beyond conventional market-based monetary approaches to also incorporate non-market monetary and non-monetary socio-cultural values.

2.3.5.1 Market-based monetary values

Market-based monetary values are predominantly focused on nature’s material contributions to people, for which a value can usually be estimated based on market prices. For example, net profits from agricultural production (across EU-28 countries) range from \$233 / ha / yr (cereals) to \$916 / ha / yr (mix crop), while the annual gross value added from wood supply in forests was \$255 / ha / yr (Table 2.7). Other market-based monetary values include avoided costs, replacement costs, mitigation costs, which may also be used to assess a wider range of nature’s contributions to people.

Table 2.7: Values for agriculture and forestry production

Land Use	Measure	Mean \$ (2017) / ha	Min \$ (2017) / ha	Max \$ (2017) / ha
Cereals ¹	Net profit	233	5	759
Dairy ¹	Net profit	718	14	6443
Mixed crop ¹	Net profit	916	243	2870
Sheep and Goats ¹	Net profit	434	79	8438
Specialist cattle ¹	Net profit	381	55	1320
Forestry (wood supply) ²	Gross value added	255	14	891

Notes:

1: Source: (Farm Accountancy Data Network, 2017) <http://www.farmbusinesssurvey.co.uk/benchmarking/Default.aspx?module=FADN>. Original data were converted to \$ (2017) using appropriate GDP deflators and the average £ to \$ exchange rate (2015)

2: Source: (Eurostat, 2016a). Forests, forestry and logging. http://ec.europa.eu/eurostat/statistics-explained/index.php/File:Economic_indicators_for_forestry_and_logging_2005_and_2013.png#file. Original data were converted to \$ (2017) using appropriate GDP deflators and the average € to \$ exchange rate (2013).

2.3.5.2 Non-market monetary values

Studies reporting the non-market monetary values of nature's contributions to people in Europe and Central Asia (electronic Appendix 2.9) are predominantly focused on Western Europe, with very little evidence found for Eastern Europe and Central Asia (**Figure 2.66**). There was some evidence that people in Central Europe have higher (standardized Int \$)²³ values for contributions from nature to people than those from Western Europe (electronic Appendix 2.9).

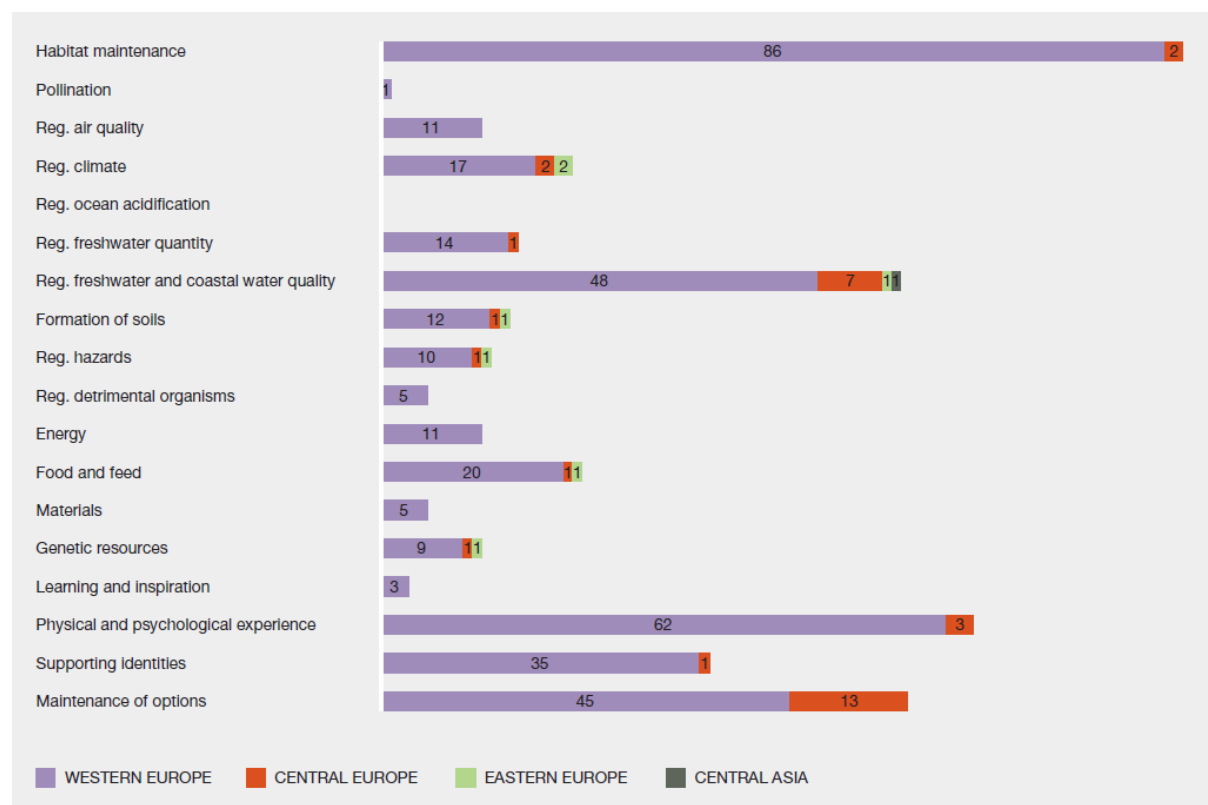


Figure 2.66: Number of value data points (i.e. individual value estimates) found for each contribution from nature to people by subregion in Europe and Central Asia. Data sources are shown in electronic Appendix 2.9.

Across all countries in Europe and Central Asia, nature's regulating contributions to people were generally the most highly valued by people for their non-market benefits (**Table 2.8**). Regulation of organisms detrimental to humans (median value = (2017) Int \$ 149 / person / yr), regulation of air quality (2017 Int \$127 / person / yr) and regulation of hazardous and extreme events (2017 Int \$112 / person / yr) achieved the highest values. Material and non-material contributions tended to have lower non-market values, with the exception of material and assistance (2017 Int \$171 / person / yr).

Analysis also explored non-market values on a per hectare basis (**Table 2.9**), although fewer data were available for these. Again, the highest values were found for nature's regulating contributions to people. Regulation of freshwater and coastal water quality (2017 Int \$1,965 / ha / yr) and habitat

²³ Following the approach adopted by The Economics of Ecosystems and Biodiversity study (TEEB, 2010), we standardized NCP monetary values to a common currency and base year (International \$ 2017). The standardization procedure adjusts values elicited in a particular currency and year to a standard currency and year using appropriate GDP deflators and purchasing power parity (PPP) exchange rates.

creation and maintenance (2017 Int \$765 / Ha / yr). Non-material contributions, such as physical and psychological experiences were also highly valued (2017 Int \$1,117 / Ha / yr. Across units of analysis, freshwater systems (2017 Int \$867 / Ha / yr) and mountains (2017 Int \$603 / Ha / yr) were most highly valued (electronic Appendix 2.9).

It should be noted that there was a wide range in the non-market values found for each of nature's contributions to people (**Tables 2.8 and 2.9**). The range in values reflects differences in both the scope and size of the contribution evaluated and differences in the methods used to assess the values. Caution is therefore advised with respect to directly transferring the reported values to other policy contexts, particularly where the valuation is based on fewer than five observations.

Table 2.8: Value per person of nature's contributions to people in Europe and Central Asia (2017 Int \$ / person / year).

	All of Europe and Central Asia		Mean	Median	Minimum	Maximum	N
REGULATING	1	Habitat creation and maintenance	114.17	41.56	1.88	913.58	59
	2	Pollination and dispersal of seeds and other propagules	53.23	53.23	53.23	53.23	1
	3	Regulation of air quality	112.94	127.5	30.37	189.86	9
	4	Regulation of climate	104.74	26.41	0.82	420.11	12
	5	Regulation of ocean acidification	-		-	-	0
	6	Regulation of freshwater quantity, location and timing	151.49	46.13	0.19	528.25	8
	7	Regulation of freshwater and coastal water quality	104.16	65.66	0.15	938.3	51
	8	Formation, protection and decontamination of soils and sediments	11.81	4.03	0.03	48.33	9
	9	Regulation of hazards and extreme events	121.63	112.34	15.07	304.58	8
	10	Regulation of organisms detrimental to humans	144.31	149.91	1.18	281.85	3
MATERIAL	11	Energy	165.02	75.29	0.78	614.08	10
	12	Food and feed	63.26	20.81	0.95	327.35	15
	13	Materials and assistance	280.13	171.41	0.31	777.37	4
	14	Medicinal, biochemical and genetic resources	138.24	33.88	4.45	844.96	11
NON-MATERIAL	15	Learning and inspiration	43.16	43.16	43.16	43.16	1
	16	Physical and psychological experience	111.44	13.57	1.35	1314.79	51
	17	Supporting identities	127.07	53.09	1.06	1399.6	32
	18	Maintenance of options	109.66	79.39	4.34	960.13	53

Electronic appendix 2.9 provides a list of data sources.

5445

5446 **Table 2.9: Value per hectare of nature's contributions to people in Europe and Central Asia (2017 Int**
 5447 **\$ / Ha / year)**

All of Europe and Central Asia		Mean	Median	Minimum	Maximum	N
REGULATING	1 Habitat creation and maintenance	1387.5	765.98	0.23	15955.53	22
	2 Pollination and dispersal of seeds and other propagules	.	.	.	.	0
	3 Regulation of air quality	289.43	289.43	289.43	289.43	1
	4 Regulation of climate	464.53	464.53	61.67	867.38	2
	5 Regulation of ocean acidification					0
	6 Regulation of freshwater quantity, location and timing	27.13	30.71	10.5	40.18	3
	7 Regulation of freshwater and coastal water quality	3202.54	1965.22	1546.62	6095.77	3
	8 Formation, protection and decontamination of soils and sediments	32.32	32.32	4.75	59.89	2
	9 Regulation of hazards and extreme events	.	.	.	.	0
	10 Regulation of organisms detrimental to humans	.	.	.	.	0
MATERIAL	11 Energy	.	.	.	.	0
	12 Food and feed	112.84	9.63	1.53	327.35	3
	13 Materials and assistance	0.66	0.66	0.66	0.66	1
	14 Medicinal, biochemical and genetic resources	.	.	.	.	0
NON-MATERIAL	15 Learning and inspiration	7.47	7.47	4.62	10.31	2
	16 Physical and psychological experience	1473.5	1117.25	22.33	3767.95	6
	17 Supporting identities	684	658.77	0.71	1392.52	3
	18 Maintenance of options	0.8	0.8	0.65	0.95	2

5448 Electronic appendix 2.9 provides a list of data sources.

5449

5450 2.3.5.3 Non-monetary values

5451 Studies reporting social-cultural values of nature's contributions to people in Western Europe and
 5452 Central Europe (see electronic Appendix 2.7) show that non-material contributions (including physical
 5453 and psychological experiences and supporting identities) are considered among the most important
 5454 contributions by people in Western and Central Europe in non-monetary terms. Food and feed, an
 5455 important category of material contributions, is also highly valued in social terms. Among regulating
 5456 contributions, habitat maintenance and regulation of freshwater quantity and quality are also

important (Figure 2.67). The highest proportion of research in social valuation of nature’s contributions to people in Western and Central Europe was undertaken in mountain grassland areas, followed by urban and semi-urban areas, cultivated areas and Mediterranean and temperate forests.

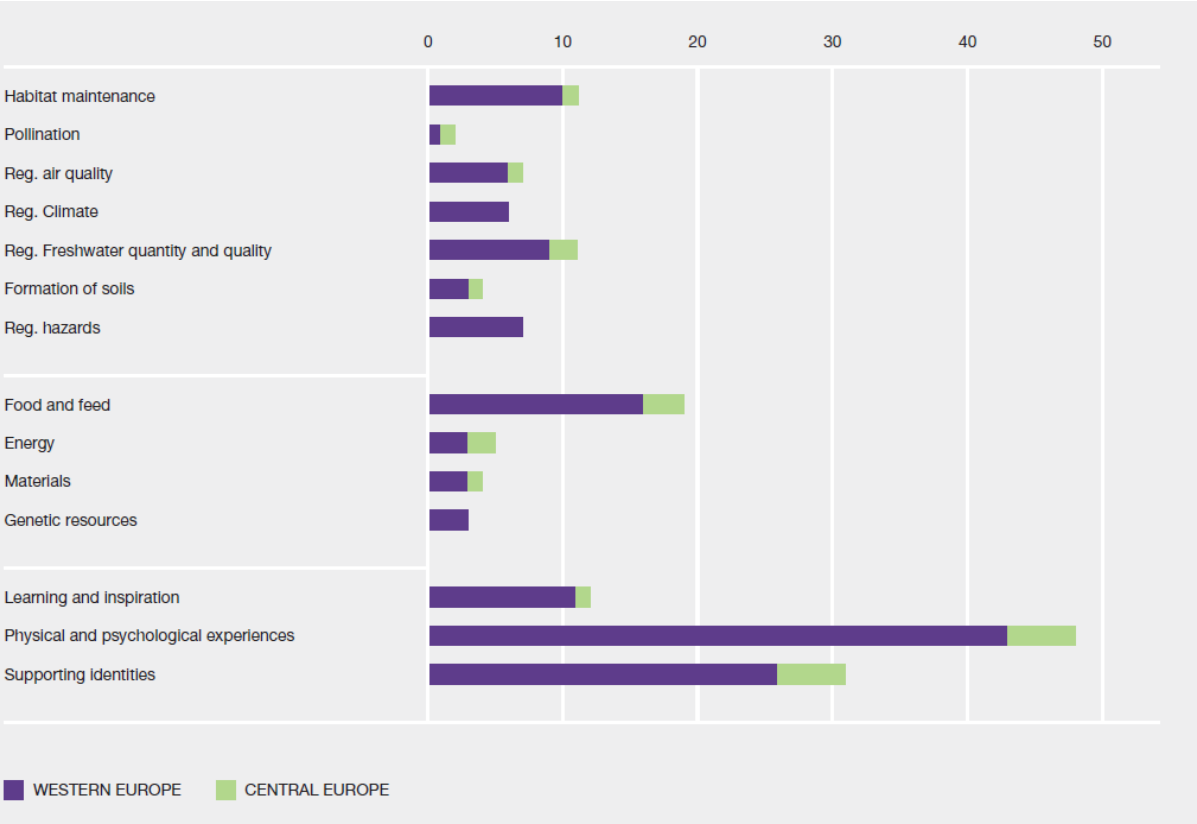


Figure 2.67: Number of publications that found each contribution from nature to people among the five most valued by people in Western and Central Europe (no data were found for Eastern Europe and Central Asia). Data sources are shown in electronic Appendix 2.7.

2.3.5.4 Integrating values into policy

Nature in Europe and Central Asia is important for making a wide range of contributions to people, to which they attach value. These values are expressed in multiple dimensions. Conventionally, nature’s material contributions to people have been valued through market prices. Evidence from Europe and Central Asia demonstrates that regulating contributions have significant non-market monetary values, while non-material contributions were demonstrated to be the most valued by people in social-cultural terms.

Assessments of nature’s contributions to people (for example to meet the Aichi Biodiversity Targets, Sustainable Development Goals should account for this plurality of values. This conclusion goes beyond the recommendations of TEEB (2010), which focused on the inclusion of non-market monetary values and concurs with ideas developed in the UK National Ecosystem Assessment (2011) and IPBES, which highlight the need to include social, cultural and shared values in decision-making through, for example, deliberation with various stakeholders (Kenter et al., 2015).

We demonstrate that alternative components of values of nature’s contributions to people are expressed in different units, and therefore may not be directly compared through, for example, conventional benefit-cost analysis. Thus, researchers and policymakers require novel approaches to

integrate value plurality into decision-making (Christie et al., 2012; IPBES, 2016a; Kenter et al., 2016; UK National Ecosystem Assessment, 2011). One such approach is multi-stakeholder spatial decision analysis (Cerreta & Panaro, 2017).

Good data on the plurality of values of nature's contributions to people exist for Western Europe, but are lacking for Central and Eastern Europe and Central Asia. There needs to be a greater focus on reporting more standardized per unit values for these contributions, where the units are clearly specified and can be compared across contributions, as this will facilitate (i) the assessment of the trade-offs of contributions between competing land uses, and (ii) the aggregation of values of contributions across the region.

2.4 Relevance to Aichi Biodiversity Targets and Sustainable Development Goals

Progress towards the Sustainable Development Goals (SDGs) and the Aichi Biodiversity Targets can be evaluated through the nature's contributions to people concept (Geijzendorffer et al., 2017). Considering the frequency with which specific contributions are mentioned in the strategies that contain these two sets of targets and goals, the direct relevance of all contributions is clear (see **Figure 2.68**). The top 25% most cited contributions across both strategies are the non-material contributions supporting identities (existence of species and ecosystems, and symbolic meaning of nature), the material contributions food and feed, and the regulating contributions habitat creation and maintenance and regulation of water quality (see **Figure 2.68**) (Geijzendorffer et al., 2017). For assessing progress towards policy goals and targets, especially Goal 2 (*zero hunger*) and Goal B of the Strategic Plan for Biodiversity 2011-2020 (*reduce the direct pressures on biodiversity and promote sustainable use*) information is required mainly on material contributions, with the latter also requiring information on regulating contributions. Information on non-material contributions are more equally needed over a range of goals and targets (Geijzendorffer et al., 2017).

To interpret whether these sustainability goals are likely to be achieved, **Figure 2.68** combines the information depicted with the assessment of each contribution from nature to people (Section 2.2.5). According to this analysis, Europe and Central Asia is not advancing in *enhancing the benefits to all people from biodiversity and ecosystem services* (Strategic Goal D of the Strategic Plan for Biodiversity 2011-2020) because of the deteriorating status of many regulating and non-material contributions from nature to people (Section 2.2.5) and because the unequal access and distribution of contributions within the region (Section 2.3.4). Finally, because the practices and knowledge of indigenous peoples and local communities in Western and Central Europe have been eroded since the 1960s, the achievement of Strategic Goal E of the Strategic Plan for Biodiversity 2011-2020 (*enhance implementation through participatory planning, knowledge management and capacity building*) is threatened. However, it is worth noting that by including indigenous and local knowledge, the IPBES Regional Assessment for Europe and Central Asia respects, and thus contributes to, the achievement of Aichi Biodiversity Target 18 (*traditional knowledge respected*).

Regarding the interlinkages between the status and trends of nature's contributions to people and the achievement of the Sustainable Development Goals, it seems that some advances have been made to accomplish those related to environmental protection (Goals 13-15). Furthermore, the active contribution of multiple contributions from nature to health is supporting the achievement of Goal 3 (*good health and well-being*). However, the impact of biofuels and agriculture expansion on increasing land grabbing rates in other regions of the world and in Eastern Europe and Central Asia due to

Western European consumption (Sections 2.2.4 and 2.3.1.1) jeopardizes the possibility of achieving Goal 2 (*zero hunger*), Goal 7 (*affordable and clean energy*) and Goal 12 (*responsible consumption and production*) in Europe and Central Asia. Further, future climate and land-use change are likely to exacerbate the decrease of water security (Goal 6). In fact, the number of water-stressed countries in Europe and Central Asia is projected to increase by 2030. Finally, the erosion of indigenous and local knowledge prevents some people from acquiring the relevant knowledge and skills needed to foster sustainable development and sustainable lifestyles and, thus, threatens the accomplishment of Goal 4 (*quality education*).

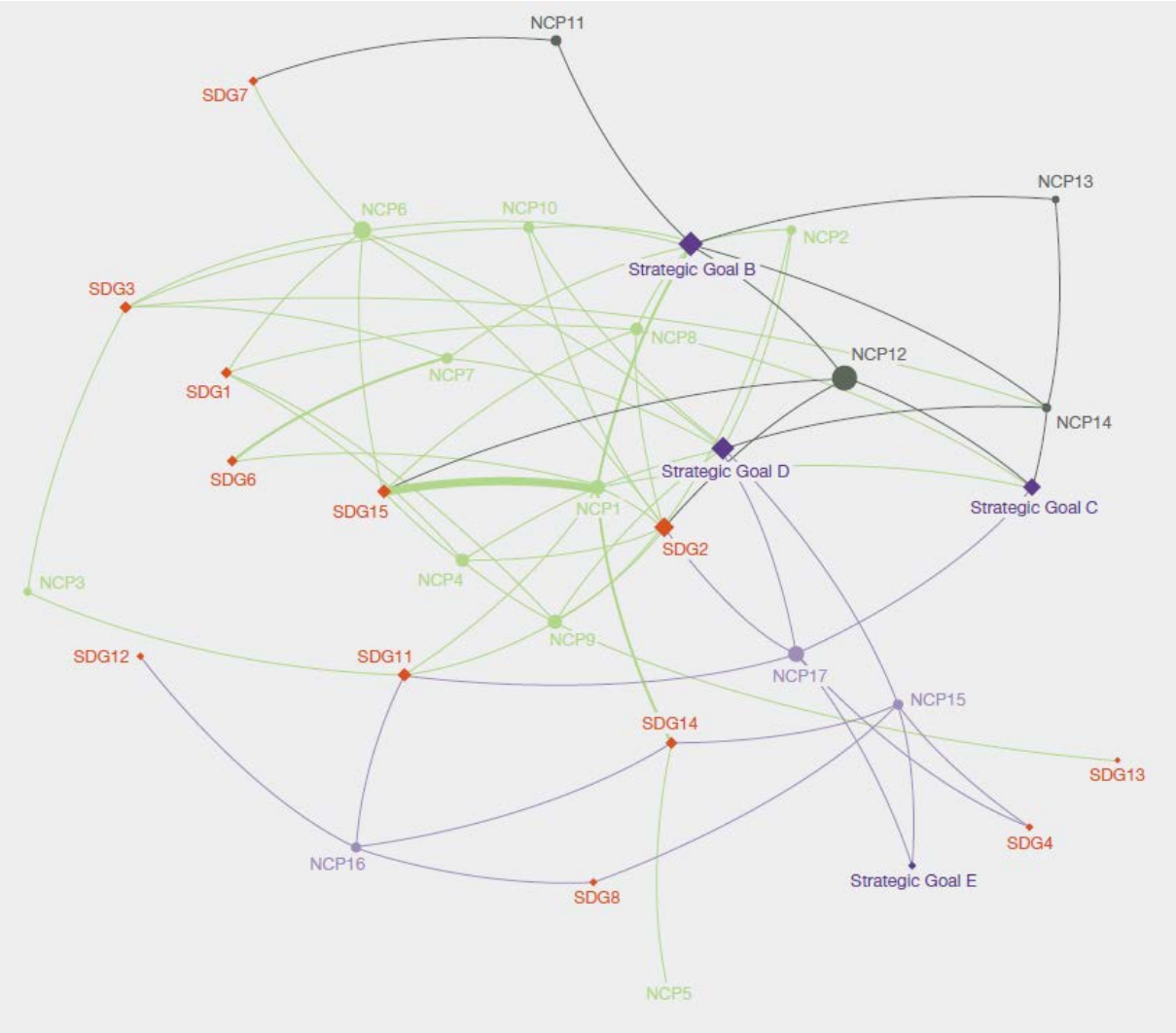


Figure 2.68: Relative importance of nature’s contributions to people (NCP) for the Sustainable Development Goals (SDGs) and the Strategic Goals of the Strategic Plan for Biodiversity 2011-2020. The width of the lines indicates the frequency at which a certain contribution was mentioned in relation to a specific Sustainable Development Goal or Aichi Biodiversity Target (goals for which no relation to nature’s contributions to people was found are not shown). The colour of the lines indicates whether the specific goal is connected with regulating (green), material (grey) or non-material (purple) contribution. The size of the nodes is proportional to the number of ties that a node has. Complete names of contributions are in Table 2.1.

2.5 Knowledge gaps

2.5.1 The unevenness of knowledge of nature's contributions to people in Europe and Central Asia

An important conclusion of this chapter's assessment of the status and trends of nature's contributions to people and their influence on quality of life is that, although there are thousands of publications and reports that are relevant to these contributions in Europe and Central Asia, a much smaller set of documents actually assess the status and trends of contributions. Furthermore, even fewer consider relationships between nature's contributions to people and good quality of life. The studies that do exist on the status and trends of nature's contributions to people are also uneven in their coverage of the different contributions. There are more accurate data on status and trends for material contributions, especially food and feed, than some regulating and non-material contributions. National ecosystem assessments often seek to analyze a range of contributions, but many publications and reports focus on individual ones. Western Europe has the most published literature on the status of nature's contributions to people and trends and their influence on the quality of life, contrasting with a very limited literature for Central Asia. Furthermore, very limited information on the status and trends in contributions is available for making comparisons between units of analysis since studies tend to focus on one or a small number of units of analysis. This conclusion, however, should be considered with caution as this chapter mostly reviewed English-language literature. *The uneven coverage in the existing literature of the different contributions for nature to people and subregions of Europe and Central Asia represents a key knowledge gap identified by the chapter.*

The limited availability of indicators for certain of nature's contributions to people in Europe and Central Asia is also a significant knowledge gap. Existing literature suggests indicator development for monitoring nature's contributions to people should cover the different components of these contributions (i.e. capacity, use and value; Section 2.1.2), provide data at multiple scales and address differences in contributions use based on societal characteristics (Balvanera et al., 2017). However, according to existing studies the kind of information and indicators that are recommended for monitoring progress towards the Aichi Biodiversity Targets indicates a bias towards information related to capacity of nature's contributions to people (Geijzendorffer et al., 2017). To implement regional and global assessment programmes of nature's contributions to people, existing studies highlight the need for indicator data at national scale for several contributions (Balvanera et al., 2017). However, there are few indicators suitable and with available data to monitor contributions properly at the national scale (IPBES, 2017c). This chapter as a whole also confirms *there is a knowledge gap regarding indicators on the use of nature's contributions to people, demand and governance, which are less developed for the Europe and Central Asia region than capacity indicators.*

Even when data are available, *a further knowledge gap is that data and indicators focus on certain points in time, and evidence on long-term historical and future trends is missing for many of nature's contributions to people.* For example, for physical and psychological experiences of nature, little information exists on temporal trends of recreationists and visitors to the different ecosystems and their related recreational benefits, particularly in marine systems (Jobstvogt et al., 2014; Ruiz-Frau et al., 2011) and forests (Turtiainen & Nuutinen, 2012). To be able to establish future trends in nature's contributions to people, more work on quantitative (e.g. modelling) and qualitative projections of the impacts of different drivers is needed and a consistency of methods and scenarios would facilitate comparison, within and across Europe and Central Asia subregions (Section 2.2.6).

Existing analyses of monitoring and indicator development for nature's contributions to people identify that this should also take place at the local scale, but local indicators must be consistent with

those at the regional and international scale in a manner that is integrated with efforts at higher levels (Balvanera et al., 2017). For particular contributions, such as spiritual experiences or medicinal resources, methodological development and assessment may fit best to the local scale, due to the importance of local differences. This chapter has identified that at the local level indigenous and local knowledge on the interactions between nature's contributions to people and quality of life should be considered alongside scientific knowledge and used for setting future management policies. *There is a knowledge gap, however, relating to the recording of indigenous and local knowledge and such information needs to be collected before it disappears* (see Section 2.2.3.1) for its own value and because it has a role to play in guiding societies towards sustainability.

This chapter has also identified specific knowledge gaps in terms of the availability of indicator data for status and trends for the following aspects of nature's contributions to people:

- *Indicators of the trends in habitat creation and maintenance*; a number of indicators can be used to evaluate its current state such as some key migratory and breeding species and their habitat and indigenous and local knowledge can also be used to assess the status and trends of this contribution from nature to people (see electronic Appendix 2.2).
- *The relationship between water use and water availability*; indicator data for freshwater quantity for Eastern Europe and Central Asia is also lacking.
- *Soil quality*; encompassing its physical, chemical and biological components.
- *Carcass removal* by vertebrate and invertebrate scavengers and marine organisms (Donazar et al., 2016; Martín-Vega & Baz, 2011; Moleón & Sánchez-Zapata, 2015).
- *The use of medicinal resources and plants*; ethnobotanical research is central to a better understanding of the medicinal potential of medicinal plants and national measures and indicators need to become comparable on an international scale, regarding health, ecological, cultural, legal or socio-economic aspects.
- *Wildlife-based tourism*; a data gap exists about accurate statistical information on the number of users developing recreational activities around wildlife (i.e. whale-watching, bird-watching).
- *Supporting identities*; there is a lack of consensus on suitable indicators but these could be developed using attitudes towards nature protection and species or ecosystem attributes or characteristics that are particularly valued for their existence (e.g. iconic, emblematic, symbolic species)
- *Interregional flows of nature's regulating and non-material contributions to people*; especially between Europe and Central Asia and other regions of the world.

This chapter also highlights some *significant knowledge gaps regarding the influence of nature's contributions to people on quality of life*. In particular, despite a large number of studies on the health aspects of nature's contributions to people in Western Europe, there are still *knowledge gaps on nature-human health linkages* in Europe and Central Asia and other regions. The current evidence base needs expanding to illuminate the scope and complexity of biodiversity-health relationships and their importance to health outcomes. More knowledge is needed on the degree to which social, cultural and economic factors influence the relationship between biodiversity, nature's contributions to people, and human health outcomes including the ways in which socio-economic status, age, gender and ethnicity can mediate health risks and benefits of nature. Such research can help to illuminate how

health-biodiversity relationships are framed or understood by different communities or vulnerable groups.

The analysis of the relationships between nature's contributions to people and environmental equity and justice across Europe and Central Asia has to address the different understandings in countries and communities as to what constitutes equity and justice. Partly because of these differences there is *limited understanding of the plural values of nature's contributions to people endorsed by different societal groups and genders*. Moreover, there is even less empirical evidence about the inequities emerging from the different control over and access to these contributions (Bennett et al., 2015). This knowledge is essential to understand fully how these contributions are likely to contribute to the quality of life of different societal groups and regions.

2.5.2 The challenges of knowledge generation on nature's contributions to people

This chapter has indicated that if status and trends in nature's contributions to people and their impact on quality of life are to be better understood across Europe and Central Asia, four key changes are required in approaches to knowledge generation on these contributions.

First, there is a need for *agreed methods that allow comparison of results and syntheses*. Each of nature's contributions to people is often studied and described in different ways and for different units of analysis, which makes it challenging to summarize status and trends for a region. For example, for the regulation of water quality, the large uncertainty in measurements and the absence of consensus on the most appropriate methods for its quantification make its assessment difficult (Clec'h et al., 2016; Grizzetti et al., 2012).

Second, there is a need for *integrative approaches that assess the multiple benefits derived from a particular contribution from nature to people*. For example, it is widely recognized that pollinators and animal-pollinated plants provide benefits not only as food and feed, but also through medicinal and symbolic plants, fibres (e.g. cotton), construction materials (e.g. some timbers), aesthetically significant landscapes (e.g. flower meadows), musical instruments (e.g. bees wax used for violins), and as sources of inspiration for art, music, literature, traditions, education and technology throughout Europe and Central Asia (IPBES, 2016b). This information on pollinators was compiled for a specific IPBES assessment on the topic, and such evidence is not available for many other contributions from nature to people.

Third, there is *limited empirical evidence on how individual contribution from nature s to people can contribute to the different dimensions of quality of life*. For example, there is only empirical evidence in Western Europe about how nature-based tourism can contribute to physical and mental health, but comprehensive information about its contributions to food security, cultural heritage and identity is missing for the whole of Europe and Central Asia.

Finally, there is a need for *more integrated approaches to the development of knowledge regarding nature's contributions to people that involve multiple social actors, including indigenous and local knowledge holders*. For example, in the case of medicinal resources, there is a need for a much more rigorous multidisciplinary science-driven approach to local and traditional medicines, which also empowers the local keepers of this knowledge and their users (Leonti & Casu, 2013). More integrated research approaches would be beneficial to better explore the knowledge and health potential of medicinal plants. It is essential to ensure that bioprospecting preserves traditional knowledge systems, and works with local communities in a manner that protects those values and protects habitats and species. Involving communities in the sustainable use of biodiversity may also provide important

5673 opportunities for local enterprise, and support the continuance of local cultural traditions. This
5674 requires direct engagement and collaboration between community organizations, biotech and
5675 pharmaceutical industries, national institutes of health and medicine, conservationists, and research
5676 funding agencies.

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2.6 References

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3 Chapter 3: Status, trends and future dynamics of biodiversity and ecosystems underpinning nature's contributions to people

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7587 **Executive Summary**

7588 **Biodiversity loss impairs ecosystem functioning and, hence, nature's contributions to people (*well***
 7589 ***established*) (3.2.1, 3.2.2, 3.2.3). Sustainable delivery of these contributions requires the**
 7590 **maintenance of genetic diversity, species diversity, and the diversity of ecosystems and land- and**
 7591 **seascapes (*well established*) (3.2.4). The delivery of individual functions over time and at different**
 7592 **places, and the delivery of multiple contributions, requires higher biodiversity than provisioning**
 7593 **single services at one place and time alone (*well established*) (3.2.5). Higher biodiversity increases**
 7594 **the capacity of terrestrial, freshwater or marine systems to capture resources, produce biomass,**
 7595 **decompose and recycle nutrients, and to provide pollination (*well established*) (3.2.1, 3.2.2).**

7596 Higher biodiversity facilitates stable ecosystem functioning and improved capacity for evolutionary
 7597 adaptation (*well established*) (3.2.3, 3.2.4). Higher biodiversity also increases ecosystem resilience and
 7598 biological control of pathogens and invasive alien species (*established but incomplete*) (3.2.1, 3.2.3). To
 7599 support ecosystem functioning, ecosystem stability over time, and adaptation to future environmental
 7600 changes, biodiversity is required at different levels, from genetic and phenotypic diversity within
 7601 populations, to diversity among populations and ecological or morphological types within species,
 7602 species diversity and phylogenetic and functional diversity within communities, and diversity of
 7603 communities, ecosystems and land and seascapes (*well established*) (3.2.3).

7604 The higher the number of nature's contributions to people, the longer the time span, and the larger the
 7605 area, the more biodiversity is required for their delivery (*well established*) (3.2.5). At the land and
 7606 seascape and larger spatial scales, biotic homogenisation, i.e. increasing similarity of the sets of
 7607 organisms found at different places, reduces nature's overall contributions to people (*established but*
 7608 *incomplete*), because of trade-offs between different facets of biodiversity and different contributions
 7609 of nature to people (*well established*) (3.2.5). Thus, at the landscape and larger spatial scale the supply
 7610 of multiple contributions of nature to people requires the maintenance and promotion of high
 7611 biodiversity (*established but incomplete*). This implies high synergy at the land and seascape level
 7612 between maintaining and promoting biodiversity and maintaining and promoting multiple
 7613 contributions of nature to people (3.2.5).

7614 **Despite including some of the best-studied marine ecosystems, most of Europe and Central Asia's**
 7615 **marine ecosystems, especially those deeper than 200m, and most marine species are data deficient**
 7616 **and their status and trends cannot be properly assessed (*well established*) (3.3.4). Of the assessed**
 7617 **marine habitats and species, a high percentage are threatened (*established but incomplete*), varying**
 7618 **between marine areas (*well established*) (3.3.4.1-7). The abundance, range and habitat size of many**
 7619 **marine species is shrinking due to human pressures (*well established*) (3.3.4.1-7, 3.4.6.1). The**
 7620 **distribution or phenology of many taxa has changed (*well established*) (3.3.4), including an**
 7621 **"Atlantification" and "Pacification" of the Arctic Sea (*established but incomplete*) (3.3.4.5). Positive**
 7622 **trends, mainly due to improved fishing practices or to a reduction in eutrophication, include increases**
 7623 **in some fish stocks in the North Sea and in plankton diversity in the Black Sea (*well established*)**
 7624 **(3.3.4.1, 3.3.4.4). Fifty-three per cent of the benthic shallow habitats in Western and Central Europe**
 7625 **are Data Deficient. This figure is 87% in the Black Sea, 60% in the North East Atlantic, 59% in the**
 7626 **Mediterranean Sea and 5% in the Baltic Sea (*well established*) (3.3.4.1-7). Of the assessed benthic**
 7627 **habitats, 38% are classified as threatened (Critically Endangered, Endangered or Vulnerable), most of**
 7628 **them in the Black (67%) and Mediterranean Seas (74%), followed by the North East Atlantic (59%) and**
 7629 **Baltic Sea (8%) (*established but incomplete*) (3.3.4.1-7). In the European Union, only 7% of marine**
 7630 **species and 9% of marine habitats of conservation interest are in "favourable conservation status",**
 7631 **while 66% of habitats and 27% of species are in 'unfavourable conservation status' (*established but***

7632 *incomplete*) (3.3.4).

7633 Of the 31.6% of marine fish with available trend data, 8.4% have declining populations (i.e., an
 7634 estimated 26.6% of all marine fish), 21.5% show no trend (i.e., 68.0% of all marine fish) and only 1.7%
 7635 are increasing (i.e., 5.4 % of all marine fish) (*well established*) (3.4.6.1). Seabirds, marine mammals and
 7636 turtles, and habitat formers, such as seagrasses and kelps, also declined in abundance (*well*
 7637 *established*) (3.4.2-4). The distribution or phenology of marine phytoplankton, zooplankton, algae,
 7638 benthic invertebrates, fishes, seabirds and mammals has changed (*well established*) (3.3.4). Such
 7639 changes are particularly visible in the Arctic Ocean, where they were classified as “Atlantification” and
 7640 “Pacification” with multiple ecosystem effects (*established but incomplete*) (3.3.4.5). Many changes in
 7641 species distribution or phenology lag behind the pace of climate change, however (*established but*
 7642 *incomplete*) (3.3.4). Forty-eight per cent of marine animal and plant species with known population
 7643 trends (436 decreasing, 59 increasing, 410 stable) have been declining in the last decade, increasing
 7644 the extinction risk of monitored species (*established but incomplete*) (3.4).

7645 **Marine habitat and species trends are driven by individual and combined effects of overfishing,**
 7646 **habitat degradation, climate change, pollution and invasive alien species (*established but***
 7647 ***incomplete*) (3.3.4.1-7).** Invasion by alien species is observed in all marine areas of the region and is
 7648 particularly fast in the Mediterranean Sea (*well established*). These invasions combined with species
 7649 range shifts, are responsible for widespread biotic homogenization between subregions and systems
 7650 (*well established*) (3.3.4.3). Invasive alien species, climate change and selective fishing reduce
 7651 taxonomic and functional diversity by increasing generalist species and decreasing specialists (*well*
 7652 *established*) (3.4). While fisheries are still the main driver of observed marine biodiversity loss across
 7653 the region, e.g. in the Mediterranean Sea (*well established*), some fish stocks also improved due to
 7654 decreased fishing pressure in some areas, e.g. the North Sea (*established but incomplete*) (3.3.4.1). In
 7655 some areas, eutrophication has decreased in recent years and e.g. plankton diversity of the Black Sea
 7656 has recovered (*established but incomplete*) (3.3.4.4). Other forms of pollution, such as plastics and
 7657 noise, negatively affect marine animals, but a full assessment of their impact is still lacking (*established*
 7658 *but incomplete*) (3.3.4).

7659 **Freshwater species and inland surface water habitats are threatened in Europe and Central Asia (*well***
 7660 ***established*).** Only 53% of the European Union’s rivers and lakes achieved good ecological status in
 7661 2015. 73% of the European Union’s freshwater habitats have an unfavourable conservation status
 7662 with wetlands, mires and bogs being the most critical (*well established*) (3.3.3.1). Across Europe and
 7663 Central Asia, lakes, ponds and streams are disappearing as a consequence of agricultural
 7664 intensification, irrigation and urban development combined with climate change (*well established*)
 7665 (3.3.3.1). The extent of wetlands in Western and Central Europe and the western parts of Eastern
 7666 Europe has declined by 60% from 1970, while 71% of fish and 60% of amphibians with known
 7667 population trends are declining (*well established*) (3.3.3.1, 3.4.5, 3.4.6.2). Over 75% of catchment
 7668 areas in Europe and Central Asia are heavily modified and subject to multiple pressures, resulting in
 7669 serious threats to biodiversity. In 2015, good chemical status, as defined by the European Union Water
 7670 Framework Directive, was not achieved for surface water bodies by 22 European Union member States
 7671 and only 53% of rivers and lakes had good ecological status, despite some improvements (*well*
 7672 *established*) (3.3.3.1). Freshwater and saline lake species and habitats are the most threatened in the
 7673 region. Most known population trends for freshwater and saline lake species have been declining,
 7674 including fish, amphibians and invertebrates. In Western and Central Europe and the western parts of
 7675 Eastern Europe at least 37% of freshwater fish and about 23% of amphibians are threatened with

7676 extinction. In the same area, freshwater invertebrates fare even worse with the most threatened
 7677 groups being gastropods (33-68% of species threatened depending on whether or not Data Deficient
 7678 species are considered threatened), bivalves (26 to 49%), crayfish (24 to 47%), crabs (16 to 65%) and
 7679 dragonflies (9 to 44%) (*established but incomplete*) (3.4.5, 3.4.6.2, 3.4.8).

7680 **The main drivers of trends in the biodiversity of inland surface waters are habitat destruction and**
 7681 **modification caused by infrastructure for hydro-power, navigation, flood protection, agriculture,**
 7682 **urban development and water abstraction; pollution from agriculture and industry; the introduction**
 7683 **of invasive alien species and their pathogens; and climate change (*established but incomplete*)**
 7684 **(3.3.3).** Many lakes, ponds and streams are disappearing as a consequence of agricultural
 7685 intensification, irrigation and urbanization combined with climate change (*well established*). Water
 7686 bodies disappear particularly in the Mediterranean region and Central Asia. Lake Akşehir, for example,
 7687 was among the largest freshwater lakes in Turkey, but has now completely disappeared due to loss of
 7688 surface and ground water sources through intensive crop irrigation (3.3.3.1). The desiccation of the
 7689 Aral Sea due to water abstraction for irrigation, followed by wind-borne pollution from former
 7690 sediments, is globally considered as a major environmental disaster (*well established*) (3.3.3.2).

7691 Water protection has progressed in Western and Central Europe, especially due to the European Union
 7692 Water Framework Directive. The rate of wetland loss has slowed considerably in Central and Western
 7693 Europe due to the implementation of binding nature conservation policies or the designation of
 7694 conservation areas (e.g. Ramsar sites). Nevertheless, the deterioration of freshwater ecosystems is
 7695 generally continuing in the region (*well established*) (3.3.3).

7696 **Most terrestrial species and natural habitats have long-term declining trends in abundance, range**
 7697 **and habitat extent and intactness. This is mainly due to agriculture, forestry, transport infrastructure,**
 7698 **urban development and climate change (*well established*) (3.3.2, 3.4).** Most natural habitats have
 7699 been declining in extent, especially subtropical and tropical forests with 20% left in Macaronesia and
 7700 10% in the Caucasus (3.3.2.5), with the highest loss occurred during the 20th century (*well established*)
 7701 (3.3.2). These declines are generally continuing, albeit at a slower rate. Forests, grasslands and tundra
 7702 have been the most impacted terrestrial habitats since the second half of the 20th century (3.3.2).
 7703 Systematic assessments of habitat conservation status only exist for the European Union. There, 15.6%
 7704 of terrestrial habitat assessments in the period 2007-2012 had favourable conservation status; 3.3%
 7705 had unfavourable, but improving trends; 36.7% had unfavourable, but stable trends; 28.8% had
 7706 unfavourable and declining trends; 11.2% had unfavorable status with unknown trend relative to the
 7707 period 2001-2006 and 4.3% had unknown status (*well established*) (3.3.2.12).

7708 Forty-two per cent of terrestrial European and Central Asian animal and plant species with known
 7709 population trends declines in the last 10 years, 6% increased and 52% were stable (3.4.13) (*established*
 7710 *but incomplete*).

7711 **The main causes of the decline of terrestrial species include habitat conversion and pollution due to**
 7712 **agriculture and forestry practices, natural resource extraction, climate change and invasive alien**
 7713 **species (*well established*) (3.4, 3.3.2).** Loss of forest biodiversity continues due to loss of intact natural
 7714 forest (*well established*), forest fires, loss of natural structures, such as dead trees (*well established*),
 7715 fragmentation of populations (*well established*), loss of traditional forestry practices that created open
 7716 forest (*well established*), increased number and strength of extreme weather events due to climate
 7717 change (*well established*) and conversion of land use (*well established*). Since the 1950s, biodiversity
 7718 has decreased in response to both abandonment of, and intensified use of, agricultural land (*well*
 7719 *established* for Western Europe and Central Europe; *established but incomplete* for Eastern Europe
 7720 and Central Asia) (3.3.2.9). The conversion of grasslands to crops and urban areas and conversion of

7721 semi-natural grassland to more intensively used pastures are among the main drivers of declining
 7722 conservation status of non-forested habitats and species (*well established*) (3.3.2.6). Climate change,
 7723 including increased number and strength of extreme weather events, also accelerates turnover in
 7724 species composition and species loss in all habitat types, shifts species distributions northwards and
 7725 upwards on mountain slopes (*well established*), decreases the extent of glaciers (*well established*),
 7726 decreases the extent of polar deserts with transformation to tundra (*well established*), expands deserts
 7727 and shifts forest cover and types (3.3.2). Populations of invasive and alien species continuously
 7728 increase in numbers, exacerbated in northern parts of Europe and Central Asia by climate change (*well*
 7729 *established*) (3.3.2).

7730 Drainage-based exploitation of boreal peatlands is gradually giving way to sustainable use, protection
 7731 and restoration, while southern and mountain peatlands are still threatened by development (*well*
 7732 *established*). Unique functions of peatlands such as carbon storage, water regulation and biodiversity
 7733 maintenance are increasingly lost by drainage and over-utilization (*well established*) (3.3.2.8).

7734 **Europe and Central Asia has over half of all known breeds of domesticated mammals and birds, but**
 7735 **75% of local bird breeds and 58% of local mammal breeds are threatened with extinction (3.4.13).**
 7736 **The species diversity of arable plants has decreased by 20% since 1950 in Western and Central**
 7737 **Europe, and the abundance of rare arable plants has also decreased (*well established*) (3.3.2.9).** The
 7738 genetic diversity of plants cultivated in situ declined until the 1960s, due to the replacement of
 7739 landraces by modern cultivars, and no further reduction or increase of diversity was observed after
 7740 the 1980s (*well established*). The numbers of at-risk animal breeds have slightly declined since 1999,
 7741 but exact quantification is hampered by the changing number of documented local breeds (*established*
 7742 *but incomplete*) (3.4.13). From 1980 to 2013, the abundance of farmland common bird species
 7743 decreased by 57% in Western and Central Europe, the abundance of grassland butterflies has declined
 7744 since 1990 (*well established* for Western Europe) and there have been severe seasonal losses of honey
 7745 bee colonies over the period 1961-2012 across Europe and Central Asia (*well established*) (3.3.2.9).

7746 **Between 44 and 68 recorded species endemic to Europe and Central Asia have become globally**
 7747 **extinct since the 15th century (40-62 animals, four to six plants). In addition, between 20 and 88**
 7748 **recorded species have become regionally extinct in Europe and Central Asia (16-80 animals, one**
 7749 **fungus and four to seven plants). 37 global extinctions involved marine and freshwater species and**
 7750 **seven involved terrestrial species, while most recorded regional extinctions were of terrestrial**
 7751 **species (*established but incomplete*). In addition to these extinctions recorded at large scale,**
 7752 **numerous extinction events were recorded at the country level (*well established*) (3.4.1).** Around
 7753 13% of animal and plant groups living in Europe and Central Asia and comprehensively assessed by
 7754 IUCN are endemic to the region (*well established*). Thirteen percent of species occurring in Europe and
 7755 Central Asia with known conservation status are at high risk of extinction. Particularly threatened are
 7756 vascular plants (32.6%), bryophytes (50%), freshwater fishes (37%) and freshwater molluscs (33-68%).
 7757 Of species endemic to Europe and Central Asia, 27.9% are threatened. The Central and Western
 7758 European subregions have the highest percentages of threatened (13.3%) and endemic species
 7759 (10.6%) and the highest percentage of threatened endemics (35.1%), with these percentages primarily
 7760 driven by the many threatened endemic species in the Mediterranean hotspot and the Macaronesian
 7761 Islands. Eastern Europe and Central Asia have lower percentages of species (<10%) and endemic
 7762 species (<5%), and lower percentages of threatened endemics (<10%) (*established but incomplete*)
 7763 (3.4.1).

7764 The net change in extinction risk for mammals, birds and amphibians is 17 species moving one category
 7765 closer to extinction every 10 years. Seven of these are in Western and Central Europe, six in Eastern
 7766 Europe and four in Central Asia (*established but incomplete*) (3.4.13). From 2007 to 2012 the

conservation status of 35 monitored plant and animal populations in EU-27 improved relative to the previous 6 years, versus 41 deteriorations (*well established*) (3.4.13). Overall, 118 monitored species of plants and animals in the European Union have unfavourable conservation status but improving trends, 572 have unfavourable conservation status and deteriorating trends and 905 have unfavourable status and stable or unknown trends (*well established*) (3.4.13).

In Western and Central Europe, the main drivers of recent past population declines across all realms are agriculture (use of biocides and chemicals affected 73% of assessed populations, intensification 42%, modification of cultivation practices 36%); reduction of habitat connectivity (55%); pollution of surface waters (56%); invasive alien species (46%); human induced changes in hydraulic conditions (43%); and forestry (removal of dead trees (39%), clearance (38%), logging of natural and plantation forests (38%)) (*well established*) (3.4.13). A separate assessment of threats to freshwater species found that at least 62% (n=13) of globally extinct species of European freshwater fishes were victims of water pollution and lake eutrophication. Destruction or modification of freshwater habitats, including water abstraction, affects 89% of amphibian threatened species and 26% of threatened freshwater invertebrates (*well established*) (3.4.5, 3.4.8). A quantitative assessment of drivers of biodiversity change in Central Asia and Eastern Europe was not possible due to a scarcity of data, but the same drivers with the addition of overexploitation (hunting, trapping, fishing, harvesting) are reported as the main causes of known trends (*established but incomplete*).

Loss of taxonomic and functional diversity driven by increasing trends and expansion of generalist species and decline of specialists is documented across Europe and Central Asia and all taxa. On land, simplification of ecosystems through land-use intensification (agriculture, forestry, and urbanization) drives this phenomenon. In inland surface waters it is due to changes in water regime, eutrophication, salinity and introduction of invasive and alien species. In the seas, the main drivers are climate change, invasive alien species and fishing of selected species (well established) (3.3, 3.4). Loss of taxonomic, and even more so, of functional diversity driven by increasing trends and expansion of generalist species and decline of specialists is documented across Europe and Central Asia for all taxa (*well established*) (3.4). Biotic homogenization in agricultural areas has occurred for a range of biological groups, including birds, butterflies, cultivated plants, weeds, and domestic animals (*well established*). Intensification of forestry and urbanization also has resulted in biotic homogenisation (*well established*) (3.3, 3.4).

Bird communities have experienced extreme levels of biotic homogenization with near-extinction of habitat specialists, especially in grasslands of Western Europe and Central Europe due to landscape simplification. Other groups disproportionately affected are migratory species (hunting and trapping) and seabirds, due to bycatch from fisheries and predation by invasive species (*well established*) (3.4). Amongst forest plants, lichens, birds, mammals and arthropods show declines of specialists of old forests and of deciduous forests, and of cavity-nesters (3.3.2.3, 3.3.2.4, 3.3.2.5, 3.4). All these changes can be related to the intensification of forestry, which does not allow the development of structural elements benefitting specialist communities (*well established*) (3.4). Among freshwater fish communities, functional homogenization exceeds taxonomic homogenization sixfold. Species that are anadromous, slow-growing, large-body sized, diet or habitat specialists have been far more impacted than others. Body-size and specialization have also played a role in biotic homogenization of zooplankton communities (*established but incomplete*) (3.4). Large-bodied and other vulnerable marine fish species are the most threatened in large parts of Europe and Central Asia, and some have gone extinct (*well established*) (3.4.6.1).

Conservation efforts have shown the potential to reverse negative population trends (well established) 3.4.13). The long-term population trends of 40% of the breeding bird taxa in Annex I of

the European Union Birds Directive are increasing compared with 31% for all breeding bird taxa (3.4.13). Charismatic mammalian mega-fauna, such as the Amur tiger, Far-Eastern leopard, Iberian lynx, and European bison are all recovering from the brink of extinction because of dedicated conservation efforts (*well established*) (3.4.3, 3.4.13). The response of biodiversity to “ecologically-friendly” agricultural practices (stricter pesticide management, reduced tillage and organic farming) is generally positive, but depends on the landscape context, spatial scale of evaluation, and biological groups - with particularly beneficial effects on plants and pollinators (*well established*) (3.4).

Overall, impacts from direct drivers on biodiversity are maintained and the use of biodiversity is not sustainable in the region (3.3, 3.4). Progress has been made in the region in terms of the extent of protected areas (3.3). However, overall trends in biodiversity are still negative (3.3, 3.4). These trends suggest that the corresponding Aichi Biodiversity Targets and Sustainable Development Goals 14 and 15 are not likely to be met (*well established*) (3.32.12, 3.3.3.3, 3.3.4.8, 3.4.13). Aichi Biodiversity Target 5 (habitat loss halved or reduced) is unlikely to be achieved given the observed status and trends in extent and biodiversity of terrestrial, inland surface water, and marine habitat (3.3.,3.4). Based on current freshwater biodiversity trends, it is highly unlikely that Europe and Central Asia will achieve the respective Aichi Biodiversity Targets by 2020 (i.e. targets, 6-10) or Target 1 of the European Union EU Biodiversity Strategy (*well established*), in spite of some progress having been made (3.4, 3.3.3, 3.5.2). Although the rate of natural habitat loss (e.g. of wetlands) has slowed down in some Europe and Central Asia countries due to the implementation of binding nature conservation policies or the designation of sites (e.g. Ramsar), the decline in freshwater habitat continues (*well established*) (3.3.3). Achieving Targets 6 (sustainable management of marine living resources) and 10 (pressures on vulnerable ecosystems reduced) is hampered for the deep-sea by increased habitat degradation and declines in biodiversity (*established but incomplete*) (3.3.4). Achieving Aichi Biodiversity Target 11 for terrestrial ecosystems (at 17% conserved through protected areas) appears to be on track, which is ensured for Western and Central Europe and likely to be met in Eastern Europe and Central Asia (chapter 4). Despite some recent progress, Aichi Biodiversity Target 11 and target 14.5 of Sustainable Development Goal 14 have still not been reached for the marine systems of Europe and Central Asia (*well established*), although they have been surpassed in some coastal areas, e.g. of the Mediterranean and North Seas, and by 15 countries protecting more than 10% of their marine waters (3.3.4.8). Some marine systems, especially those further from the coast, are much less protected, however (*well established*). Downward trends in the conservation status of assessed taxa indicate that the Europe and Central Asia region is not on track to meet Target 12, in spite of some decreasing trends in extinction risk (*well established*) (3.4). Despite some progress towards Target 13 (genetic diversity maintained) by developing safeguards for rare domestic breeds and germplasms of cultivated plants, the extinction risk of domestic animal breeds is increasing and genetic diversity of cultivated plants eroding under modern production systems (*established but incomplete*) (3.4.13). Despite advances in protected areas (relevant in the context of Sustainable Development Goals 14 – life below water and 15 – life on land), the negative trends observed for biodiversity currently restrict progress toward Goals 14 and 15 (*well established*) (3.3).

Under business as usual scenarios of future global change, the extent of coniferous forests is expected to be maintained or even increase. Meanwhile, tundra, other Alpine ecosystems, Mediterranean ecosystems, and broad-leaved and mixed forests are expected to substantially contract, because of climate and land-use change. Alpine, Scandinavian, and Icelandic glaciers are projected to retreat (3.5.1.3) (*well established*). The expected range of glacier losses depends on climate modelling scenario and varies from 20% to 90% of the 2006 ice volume. Climate change is also expected to further increase the stress on freshwater ecosystems, not only by changing species distribution but also by exacerbating the symptoms of eutrophication due to loss of planktivorous

species through warming and salinization (*inconclusive*) (3.5.2). Mean species abundance, local functional and phylogenetic diversity and between-sites taxonomic diversity are expected to decrease throughout the 21st century, while local taxonomic diversity is expected to increase in some terrestrial and marine regions as a result of climate-driven range shifts (*established but incomplete*) (3.5.1, 3.5.3). Across species, range contractions are projected to be between 10% and 55% depending on climate scenario and taxonomic group considered (*established but incomplete*) (3.5.1.1). Biomass productivity may increase in some areas due to CO₂ fertilization and temperature increase, especially in the Arctic seas, lakes and boreal forests (*unresolved*) (3.5.1, 3.5.2, 3.5.3).

If key knowledge gaps would be addressed soon, future assessments could provide a more comprehensive account of the relationship between biodiversity and nature's contributions to people and of the status and trends of nature (*well established*) (3.6). Much more information is available on the relationship between biodiversity and ecosystem services from experiments than from the field. Among the experiments those manipulating plant diversity were overrepresented compared with those manipulating other taxa, and most concerned grasslands or aquatic mesocosms. For experiments and field studies addressing the relationship between biodiversity and ecosystem services, comprehensive information across all types of nature's contributions is not yet available (*well established*) (3.2, 3.6).

A broader knowledge basis on trends in habitat extent, intactness and species conservation status was available for Western and most of Central Europe than for Eastern Europe, Central Asia and Balkan countries in Central Europe (3.4, 3.6). For example, exact extent, biodiversity status and trends are hardly known for most terrestrial and freshwater ecosystems in Eastern Europe and Central Asia, and the chemical status of 40% of Western and Central Europe's surface waters remains unknown (*well established*). Biodiversity status and trends are also poorly known for most marine habitats. E.g. 30% of coastal marine habitat assessments in the Mediterranean reported unknown conservation status. Only a minor fraction of the deep-sea floor and of known seamounts have been subject to biological investigation (*well established*) (3.4, 3.6).

Major gaps on status and trends of taxonomic groups concerned invertebrates, most marine and freshwater species, bryophytes, lichens, fungi and microorganisms. Of the estimated 32,000 vascular plant species of Europe and Central Asia, IUCN evaluated 2483 (approx. 8%) in the Red List of Threatened Species. Of the estimated more than 2000 bryophyte and more than 7000 lichen species in the region only 14 and 5 species, respectively, have been evaluated in the IUCN Red List. For invertebrates in general, and freshwater invertebrates in particular, even the current status is available only for a minority of species. Almost a quarter of all European freshwater molluscs are Data Deficient, many of them likely to be threatened. 76% of freshwater fishes and 83% of freshwater molluscs assessed have unknown population trends (*well established*) (3.4). One to two thirds of marine species are still to be described. Status and trends for marine biodiversity are mostly unknown, even for coastal habitats. Accordingly, 50% of the assessments under the European Union habitat directives reported unknown conservation status for cetaceans and turtles and coastal marine habitats in the Macaronesian biogeographic region. E.g., 30% of coastal marine habitat assessments in the Mediterranean reported unknown conservation status. Only a minor fraction of the deep-sea floor and of known seamounts have been subject to biological investigation (*well established*) (3.3., 3.4, 3.6). Indigenous and local knowledge on biodiversity trends was only partially available (*well established*) (3.6).

Due to lack of quantitative knowledge the relative role of drivers of change in determining trends in extent and intactness of habitats and in species diversity and abundance could only be attributed in

7905 terms of a coarse classification. Moreover, information is lacking on the interacting effects of several
7906 drivers on biodiversity (*well established*) (3.3, 3.4, 3.6)

7907 These knowledge gaps greatly reduce the ability to monitor progress towards international biodiversity
7908 targets and to inform policy to avert further biodiversity loss. For example, current instruments such
7909 as the European Union habitat directive and Natura 2000 program do not consider algae, fungi or
7910 lichens, and only a small fraction of invertebrates (*well established*) (3.6).

7911

3.1 Introduction

This chapter assesses, for Europe and Central Asia, evidence for the general role of biodiversity for nature's contributions to people (3.2). Then it assesses the past and current status and trends of terrestrial, inland surface water and marine biodiversity by ecosystems (units of analysis) (3.3) and by taxa (3.4). This is followed by an assessment of future trends of terrestrial, inland surface water and marine biodiversity (3.5). Finally this chapter assesses knowledge gaps (3.6) in these respects.

Whereas Chapter 2 of the IPBES Regional Assessment for Europe and Central Asia identifies strong evidence that nature's contributions to people are declining, this chapter provides an assessment of the general underpinning of nature's contributions to people by biodiversity. Moreover, while Chapter 4 establishes that natural resource extraction, land-use change, pollution, climate change, and invasive alien species are the main direct drivers driving biodiversity change in general, this chapter assesses the status and trends of marine, inland surface water and terrestrial biodiversity for different units of analysis and for different taxa, and it attributes these trends to the direct drivers.

3.2 The relationship between biodiversity and ecosystem functions and services

3.2.1 General importance of biodiversity for ecosystem functions and services

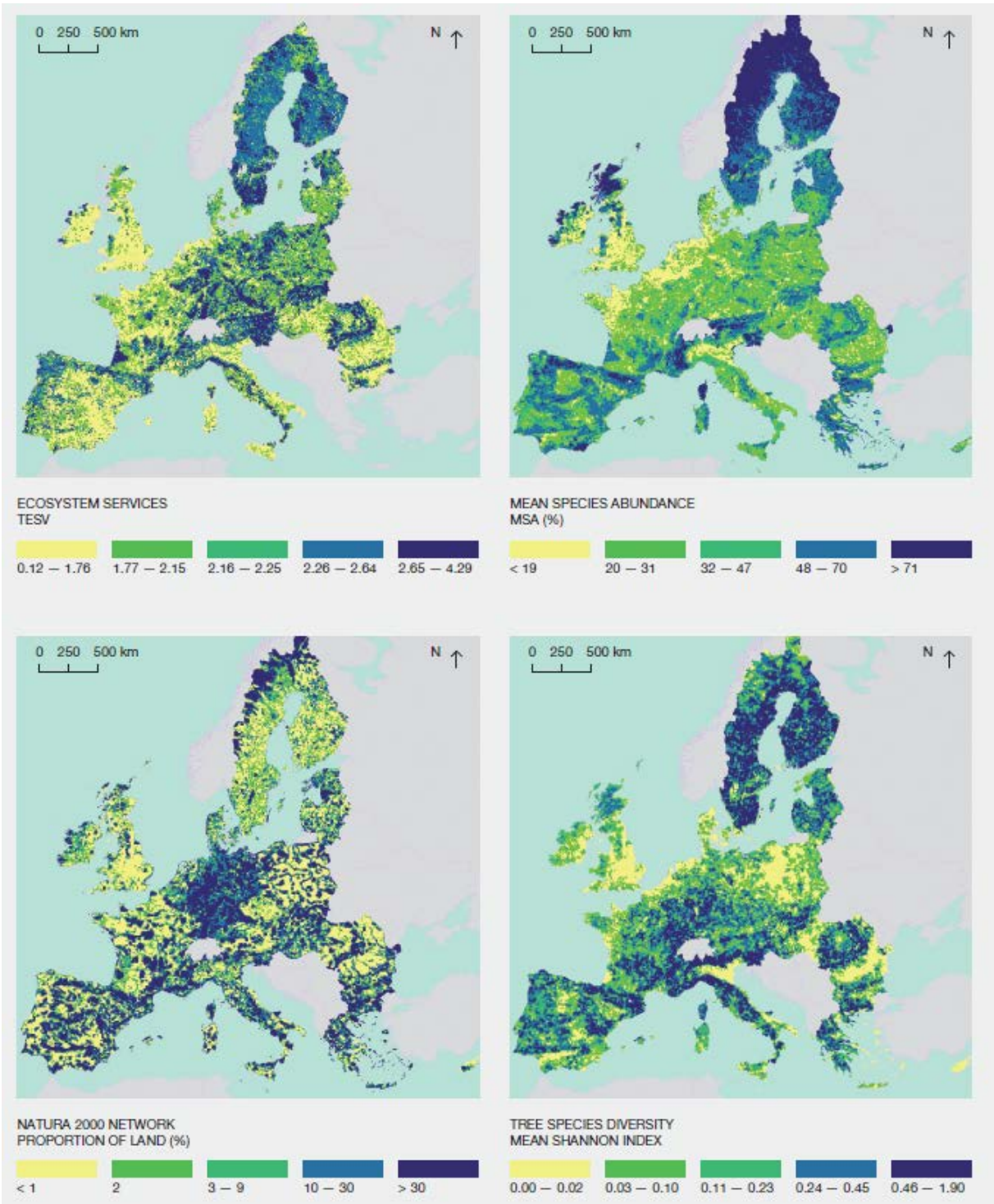
Theoretical, experimental and field studies have proven that biodiversity is one of the key factors in determining the mean level and stability of ecosystem properties and functioning, such as biomass production, decomposition and carbon sequestration (Cardinale et al., 2012; Tilman et al., 2014). Clear evidence of biodiversity effects on ecosystem functioning has been obtained from experiments, which overall showed that the impacts of diversity loss on ecological processes are of comparable magnitude to the effects of other global drivers of environmental changes such as climate change, ultraviolet radiation, increase in the concentration of CO₂, nitrogen addition, droughts and fires (Cardinale et al. 2012; Hooper et al., 2012; Tilman et al., 2012). Experiments can even underestimate biodiversity effects because they do not assess important properties of natural systems that enhance the positive diversity effects, such as complex trophic structures, complementary and mutualistic interspecific relations, non-random biodiversity loss and spatial heterogeneity (Cardinale et al. 2012; Duffy et al., 2009; electronic Appendix 3.1). In addition, biodiversity effects increase with time and at larger spatial scales (Cardinale et al. 2012; electronic Appendix 3.1), which means they may be stronger in real-world systems than in experiments. On the other hand, the range of species richness loss studied in typical biodiversity experiments is far greater than real world biodiversity loss (Vellend et al., 2013).

Comparative field studies have the great potential to show the relevance of biodiversity in real world ecosystems, but they are often not suitable for demonstrating the causality of observed relationships and have difficulties in distinguishing the effects of biodiversity, versus environmental drivers, on ecosystem functioning. Thus, the analysis of field observations needs to separate effects of diversity from other confounding factors (electronic Appendix 3.1).

In addition to the general consensus about the key role of biodiversity in ecosystem functioning, there is increasing information on the relationships between biodiversity and ecosystem services and, hence, nature's contributions to people (Balvanera et al., 2014). A comprehensive systematic literature review (Harrison et al., 2014) showed that the majority of relationships between biodiversity attributes and the selected 11 ecosystem services were positive. The key role of biodiversity was demonstrated for certain provisioning services (such as wood production in plantations, production of fodder in

7955 grasslands, and stability of fisheries yields); and regulating services (such as pollination, resistance to
7956 exotic plant invasions and plant pathogens, aboveground carbon sequestration, soil nutrient
7957 mineralization, and bioremediation of contaminated water and sediments (Cardinale et al., 2012;
7958 Harrison et al., 2014; Science for Environment Policy, 2015; Thompson et al., 2012). For many other
7959 ecosystem services (e.g. long-term carbon storage, suppression of pests and animal disease), the
7960 evidence for biodiversity effects is mixed or there are still insufficient data (Balvanera et al., 2014;
7961 Cardinale et al., 2012). Overall, however, the evidence to date suggests that sustaining the long-term
7962 flow of many ecosystem services will require high levels of biodiversity (Science for Environment Policy,
7963 2015).

7964 In Europe and Central Asia, field studies revealed generally positive effects of biodiversity on
7965 ecosystem services. A European Union-wide assessment (Maes et al., 2012) showed that biodiversity
7966 indicators (mean species abundance, tree species diversity and the relative area of Natura 2000 sites)
7967 and ecosystem service supply (aggregated index of four provisioning services, five regulating services
7968 and one cultural service) were positively correlated with each other (**Figure 3.1**). Overall, habitats in a
7969 positive conservation status provided higher levels of biodiversity indicators and had a higher potential
7970 to supply ecosystem services, particularly regulating and cultural services, than unprotected areas.



7971

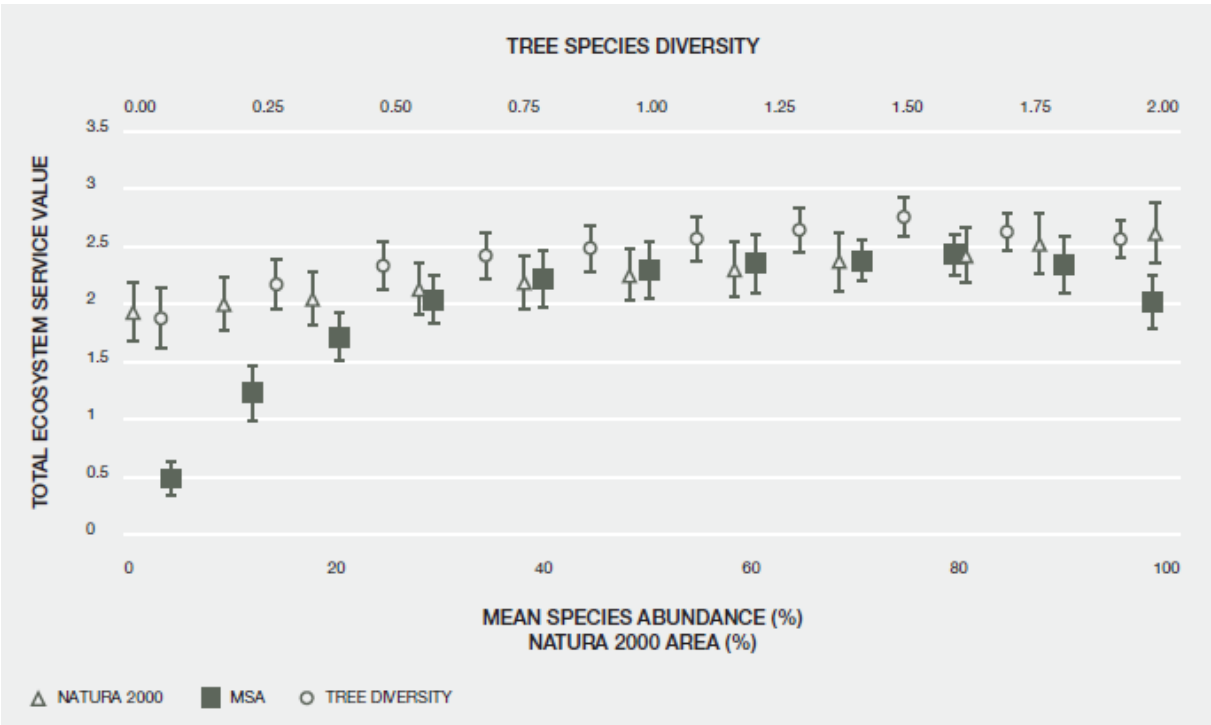


Figure 3.1: from Maes et al., 2012: Large-scale relationship between biodiversity and ecosystem service supply in the European Union. Top panel: Biodiversity and ecosystem services maps. Top left: Total ecosystem service supply calculated as the sum of standardized values for 10 ecosystem service indicators. Top right: Mean Species Abundance. Bottom left: The proportion of protected areas which are part of the Natura 2000 network. Bottom right: The forest tree species diversity measured using the average Shannon Wiener Diversity Index. Bottom panel: Relationship between biodiversity and total ecosystem service supply. Biodiversity is represented using three spatial indicators: Mean Species Abundance (MSA), forest tree species diversity and relative surface area of the Natura 2000 network. Ecosystem service supply is represented by total ecosystem service value. Dots represent the average value of total ecosystem service value for equally distributed classes of the biodiversity proxies. Error bars represent standard deviations.

An analysis of data of the UK National Ecosystem Assessment showed that biodiversity plays a key role in providing various types of ecosystem services: as a regulator of ecosystem processes, in providing final ecosystem services, and as a good with intrinsic value (Mace et al., 2012).

An analysis of Swedish forest inventory data showed that relationships between tree species richness and several ecosystem services (production of tree biomass, soil carbon storage, berry production and game production) were positively linear to positively unimodal (Gamfeldt et al. 2013). Importantly, no single tree species was able to promote all services, emphasising the need for planting multiple tree species in forest stands to maintain multiple ecosystem services.

Regional studies in Finland (Hanski, 2014; Hanski et al., 2012) confirmed that biodiversity increased immune regulation (von Hertzen et al., 2011) and thus extended the view on ecosystem services to the field of maintaining human health. The findings suggest that loss of biodiversity reduces human exposure to beneficial environmental microbes, with essential immunoregulatory functions and, thus, leads to increasing prevalence of allergies and other chronic inflammatory diseases among urban populations worldwide.

7999 3.2.2 Positive effect of biodiversity on the magnitude of ecosystem functioning

8000 A scientific consensus has been reached that “there is now unequivocal evidence that biodiversity loss
8001 reduces the efficiency by which ecological communities capture biologically essential resources,
8002 produce biomass, decompose and recycle biologically essential nutrients” (Cardinale et al., 2012). Both
8003 diversity within species (intraspecific diversity) and species diversity within communities are important
8004 for ecosystem functioning.

8005 Numerous theoretical models describe how competition between individuals of both the same and
8006 different species predicts positive effects of species and functional diversity on biomass production
8007 and effectiveness of resource use (Tilman et al., 2014). Several hypotheses predict that effects of
8008 diversity are more complex and variable in multi-trophic systems, i.e. of systems involving species of
8009 different trophic levels of the same food web (see electronic Appendix 3.1). Population genetics
8010 provides a theoretical foundation for the key importance of diversity within a population for
8011 population fitness (Lavergne et al., 2010; Wennersten, Forsman, 2012) and thus, their capacity to
8012 provide ecosystem functions and services. Theory distinguishes two main classes of mechanisms by
8013 which diversity can positively affect ecosystem processes: a) complementarity effects, i.e. functional
8014 complementarity in, for example, resource use of species or genotypes or phenotypes or due to
8015 positive (facilitative) species interactions; and b) selection effects, i.e. selection of particular functional
8016 traits of species or genotypes or phenotypes, with beneficial effects for ecosystem processes (for
8017 example the tendency of fast-growing plant species to become dominant in diverse communities)
8018 (Bolnick et al., 2011; Forsman, Wennersten, 2016; Hughes et al., 2008; Loreau, 2010).

8019 Meta-analyses and reviews of hundreds of experiments revealed predominantly positive effects of
8020 species richness on community-level functioning (productivity, biomass, abundance, rate of nutrient
8021 cycling, invasion resistance, etc.). Negative effects were also found, but to a lesser extent (**Figure 3.2**)
8022 (Bardgett, van der Putten, 2014; Cardinale et al., 2012; Gamfeldt et al., 2015; Handa et al. 2014;
8023 electronic Appendix 3.1). Dozens of experiments with bacteria, plants, and invertebrate and vertebrate
8024 animals, showed positive effects of genetic diversity on ecosystem functioning (Forsman, 2014;
8025 Forsman, Wennersten, 2016; Hughes et al., 2008; electronic Appendix 3.1). At the population level,
8026 high genetic diversity increases productivity, biomass, fitness, resistance and stability. At the
8027 community level, high genetic diversity (per species) decreases the probability of alien species
8028 invasions, disease levels, and increases the abundance and species diversity of consumers. At the
8029 ecosystem level, high genetic diversity in dominant plant species increases decomposition rates and
8030 nutrient cycling (Forsman, 2014; Forsman, Wennersten, 2016; Hughes et al., 2008).

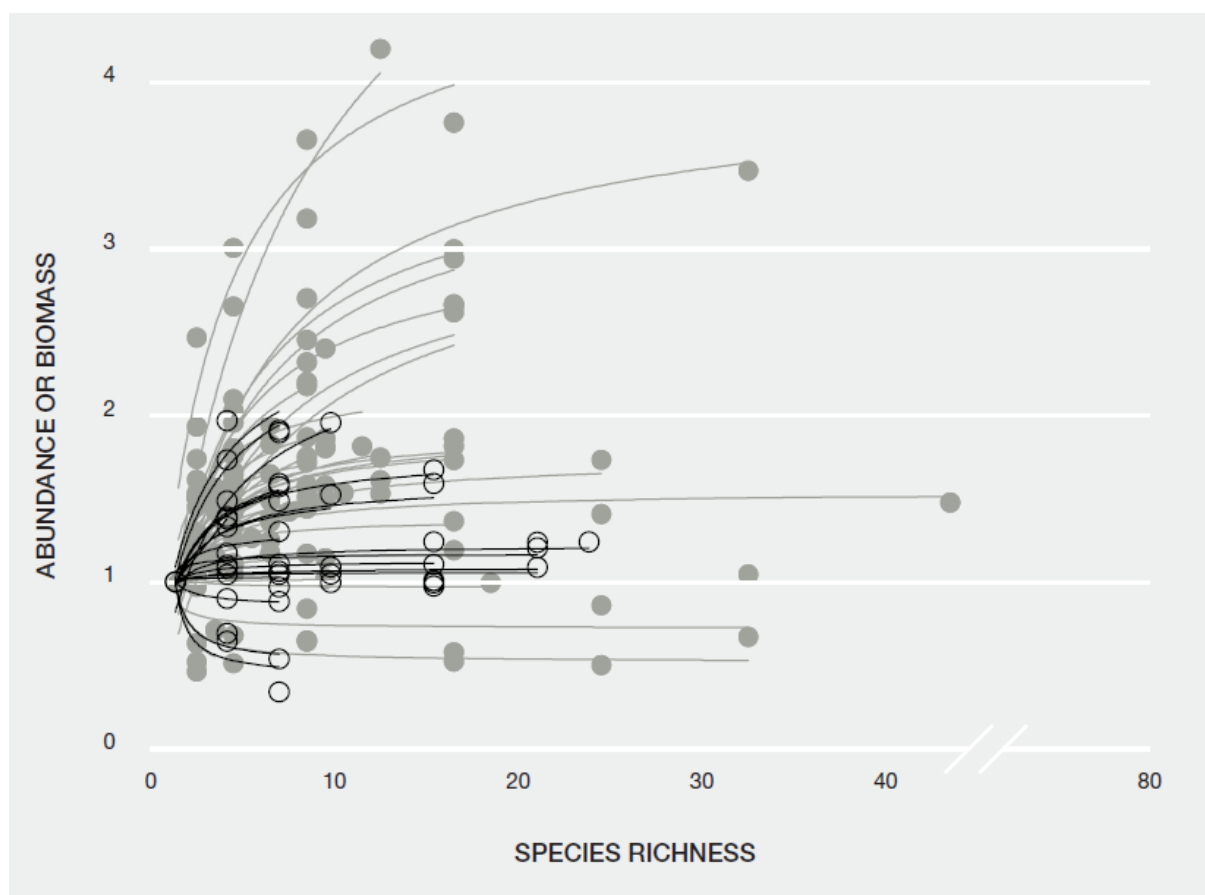


Figure 3.2: The general form of the diversity–biomass production relationship. Effects of species richness on the standing stock abundance or biomass of the same trophic group. Each curve corresponds to data from a single study (grey circles and lines - terrestrial studies, black circles and lines – aquatic studies) (from Cardinale et al. (2006)).

Comparative field studies also demonstrated positive impacts of species and functional diversity on ecosystem functioning (productivity, biomass, aboveground carbon stocks, soil carbon content, nutrient cycling, resource use efficiency) in real-world terrestrial, freshwater and marine ecosystems across the world (Grace et al., 2016; Lewandowska et al., 2016; Maestre et al., 2016; Mora et al., 2011; electronic Appendix 3.1). Field observations of plants, invertebrates, amphibians, reptiles, birds and mammals confirmed the importance of intraspecific diversity for population fitness and functioning (Forsman, Wennersten, 2016; Hughes et al., 2008) that was also expressed in a decline of fitness and adaptability due to a loss of genetic diversity in small or anthropogenically disturbed populations (see electronic Appendix 3.1).

More specifically, comparative field observations also showed that positive biodiversity effects are widespread in Europe and Central Asia. Analysis of forests across Western and Central Europe revealed positive effect of tree species richness on biomass production (Jucker et al., 2014, 2016; Vila, 2013). Eight Western and Central European field studies of five animal groups (bees, carabid beetles, earthworms, soil nematodes and dung beetles), which deliver several key ecosystem functions (pollination, biocontrol of pests and weeds, bioturbation, nutrient cycling) revealed a positive relationship between functional diversity and ecosystem functioning provided by animals (Gagic et al., 2015).

The shape of the relationship between biodiversity and ecosystem functioning is crucially important for ecological management. Most experiments that manipulated species richness revealed an asymptotic saturating relationship (Panel A in **Figure 3.3**) between diversity and ecosystem processes

(Cardinale et al., 2006, 2012). Most experiments that manipulated genetic diversity revealed a positive linear relationship (B in **Figure 3.3**) (Forsman, Wennersten, 2016). However, two recent large-scale field observational studies on sea communities detected exponential relationships (C in **Figure 3.3**) (Danovaro et al., 2008; Mora et al., 2011).

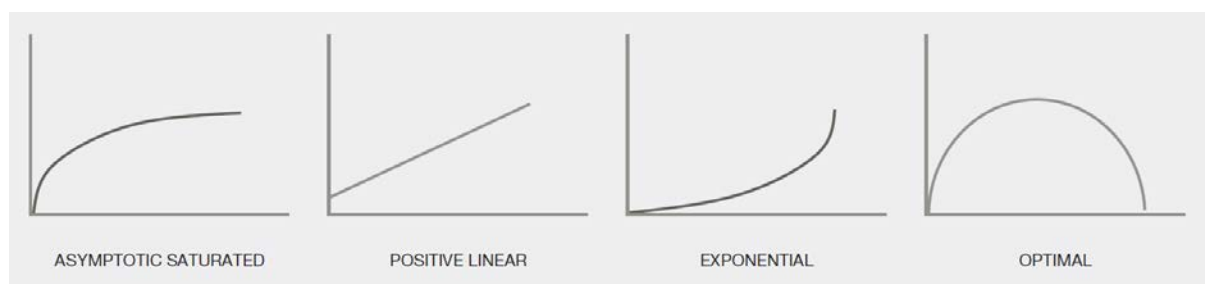


Figure 3.3: Shapes of relationships between biodiversity and ecosystem processes. From left to right: asymptotic saturated; positive linear; exponential; optimal.

The asymptotically saturating pattern found in many experiments implies that the loss in ecosystem functioning accelerates as biodiversity loss increases. This suggests that the loss of a few species from a very species-rich community may have less deleterious consequences for ecosystem functioning than the loss of species from a species-poor community. In the case of a linear relationship, the loss of any species will equally decrease functioning. In the case of an exponential pattern, the loss of species will even cause an exponential decline in ecosystem functioning (Danovaro et al., 2008; Loreau, 2008; Mora et al., 2014). The unimodal shape suggests that there are optimal diversity values that correspond to maximum levels of ecosystem functioning, thus both a decrease and increase of diversity away from the optimal values leads to reduced ecosystem functioning. The optimal diversity values can often be regarded as typical for undisturbed populations and communities, which would suggest that the preservation of typical diversity may at the same time maintain ecosystem functioning (see 3.1.4).

Theoretically, the shape of the relationship between species richness and ecosystem processes depends on the degree of species niche overlapping and dominance - if species niches largely overlap (species are functionally redundant) the relationship is asymptotically saturating. If niches practically do not overlap (species carry out different functions) the relationship is close to linear (Loreau, 2000; Petchey, 2000; Tilman et al (2014). Mutualistic species interrelations can cause an exponential relationship (Loreau, 2008). The order of species extinctions also changes the shape of the relationship, particularly, saturating relationships are observed when species go extinct from the least efficient to the most efficient and exponential relationships when species are lost in the reverse order (see electronic Appendix 3.1). Unimodal relationships occur when ecosystem functioning peaks at intermediate biodiversity (D in **Figure 3.3**) and are predicted by some theoretical models (Bond, Chase, 2002; Bukvareva, Aleshchenko, 2013; Bukvareva, 2014). These were detected in some experiments manipulating genetic diversity (Caesar et al., 2010; Burls et al., 2014) and in wild populations of spruce and salmon (Altukhov, 2003). Experiments with communities of littoral psammophilous (i.e. sand-living) ciliates of the White Sea showed that the width of the group's trophic niche (i.e. the suite of used resources) was highest at intermediate species richness (Azovsky, 1989). Passy and Legendre (2006) found the highest biovolume (a surrogate for biomass) of algae at intermediate species richness in freshwater communities.

3.2.3 Effects of biodiversity on stability and resilience of ecosystem functioning

There is now a consensus that biodiversity increases the stability of ecosystem functions through time (Cardinale *et al.* 2012). Theoretical models predict that community stability is an increasing function of species richness, while population stability often decreases with species richness (Tilman *et al.*, 2014). Two main hypotheses known as the “portfolio effect” and the “insurance hypothesis” predict a stabilizing effect of species diversity. The “portfolio effect” posits higher likelihood of stabilization due to asynchrony in species responses to environmental fluctuations and stochastic ecological mechanisms, where the decline of one species is compensated by an increase in another species (Loreau, 2010; electronic Appendix 3.1). The “insurance hypothesis”, positing that more diverse communities have a higher likelihood that at least some species function well under various conditions, was supported by simulation models using data of Central European forests (Morin *et al.*, 2014). Population models predict that similar mechanisms can provide stabilizing effects of intra-population diversity on populations and species (Bolnick *et al.*, 2011; Forsman, Wennersten, 2016; Hughes *et al.*, 2008; electronic Appendix 3.1). There is also evidence that resilience of ecosystem functioning (i.e. maintenance of ecosystem functioning under a range of environmental perturbations that could occur in the near future) is ensured by all levels of biodiversity - intraspecific genetic diversity, adaptive phenotypic plasticity, species diversity and spatial heterogeneity of habitats (Oliver *et al.*, 2015).

Grassland experiments fully confirmed theoretical assumptions showing that community stability increases with species richness due to averaging effects, while population stability decreases with species richness due to smaller population sizes (Griffin *et al.*, 2009; Gross *et al.*, 2014; Hector *et al.*, 2010; Tilman *et al.*, 2014; electronic Appendix 3.1). Furthermore, field observations in grasslands across five continents also showed positive relationships between species richness and stability in biomass production, but only in un-manipulated communities of non-fertilized grasslands (Hautier *et al.*, 2014). The importance of intraspecific diversity for population stability has been demonstrated for wild fish populations (see electronic Appendix 3.1).

In Western and Central Europe, forest surveys showed that aboveground wood production is more stable in forests with higher tree species richness due to asynchronous responses of species to climate and due to greater temporal stability in the growth rates of individual tree species. Thus, the central role of diversity in stabilizing productivity was revealed for European forests (Jucker *et al.* 2014). Furthermore, studies of inter-annual fluctuations of 2,671 plant, arthropod, bird and bat species in German forests and grasslands demonstrated that species diversity provides community stability due to asynchronous changes in the abundance of different species (**Figure 3.4**, Blüthgen *et al.*, 2016).

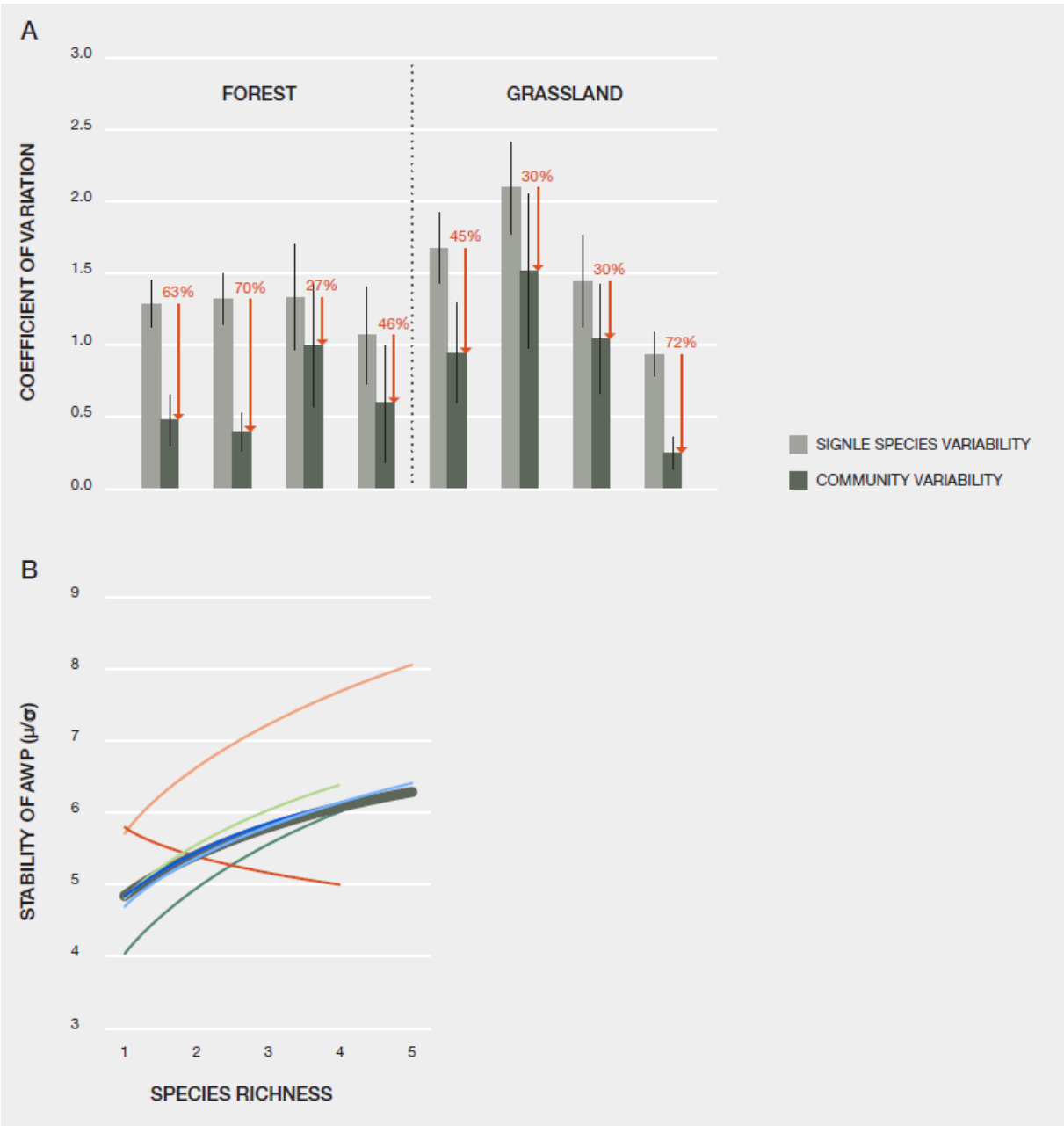


Figure 3.4: Top panel: Copied from Blüthgen et al. (2016). Biomass stability in diverse grassland and forest communities is higher than within single species. Communities had a lower inter-annual variability in total abundance than single species. The figure shows strong decreases in total abundance variability — and thus increased stability (arrows) — compared with the mean species variability, resulting from portfolio effects and species asynchrony. Four taxa with multiple species (arthropods, birds, bats and plants) in forests and grasslands were compared. Differences in stability between forests and grasslands in interaction with taxon were highly significant, whereas the relative stability gain between the two habitats was not. **Bottom panel:** Copied from Jucker et al., 2014. Community stability as a function of forest tree diversity. The graph shows the fitted relationship between stability of aboveground wood production (AWP) and species richness across the entire plot network (black line) and for each site separately (coloured lines: Spain = red; Italy = orange; Germany = dark green; Romania = light green; Poland = light blue; Finland = dark blue).

3.2.4 Importance of all hierarchical levels of biodiversity

Measures of diversity other than species diversity have received less attention in literature on biodiversity and ecosystem functioning. However, intra-population diversity (i.e. genetic and phenotypic variation within populations) and intraspecific diversity (i.e. local populations, ecological and morphological forms composing species) are crucially important for fitness, adaptability and long-term viability of populations and species (Lavergne et al., 2010). Maintaining the evolutionary perspective of species and ecosystems is necessary to ensure ecosystem functioning and services into the future, while the loss of intra-population or intraspecific diversity undermines species' ability to adapt and evolve in a changing environment (Lavergne et al., 2010; electronic Appendix 3.1). The loss of intra-population or intra-specific diversity also weakens and destabilizes ecosystem functioning (3.1.2 and 3.1.3). Diversity assessments that ignore intraspecific diversity may underestimate biodiversity changes and even lead to ineffective conservation practices. This is highly risky, since the loss of intra-specific diversity is already occurring and is projected to continue in the future in Europe and Central Asia (Balint et al., 2011; Habel et al., 2011; Neaves et al., 2015; Pauls et al., 2013; Taubmann et al., 2011).

Experimental and field studies demonstrated that functional diversity (i.e. diversity of species functional traits or diversity of functional groups of species) is no less important than species diversity (Cardinale et al., 2012; Cadotte et al., 2011; Gagic et al., 2015; Gamfeldt et al., 2015; Gravel et al., 2016; Lefcheck et al., 2015; Mouchet et al., 2010; electronic Appendix 3.1). Functional traits both of key species and rare species are important because the former have a large influence on community productivity (Cardinale et al., 2012) and the latter can provide the most distinct trait combinations (Mouillot et al., 2013). Phylogenetic diversity is the variation in the evolutionary origin of co-occurring species. It can be important for ecosystem functioning along with species and functional diversity (Cardinale et al. 2012; Mace et al., 2003) (see electronic Appendix 3.1). Functional and phylogenetic homogenization across Europe were predicted for plants, birds and mammals, due to changes of climate and land use (Thuiller et al., 2011, 2014). Phylogenetic diversity over multiple taxonomic groups is considered as indicator of nature's contribution to people number 18, maintenance of option (Faith, 1992, Gascon et al., 2015, Faith, 2017; Chapter 2, Section 2.2.3.4). Thus, accounting for these biodiversity facets appears important for the prediction of future ecosystem functions and services.

The structure of interspecific relations, including food webs, is also a key feature of biodiversity. Particularly, there is now consensus that the "loss of diversity across trophic levels has the potential to influence ecosystem functions even more strongly than diversity loss within trophic levels" (Cardinale et al., 2012). Experiments and simulations demonstrated the importance of the structure of food webs for ecosystem functioning. For example, the loss of consumers at higher trophic levels can cascade through a food web to influence structure and functioning of the whole ecosystem (see electronic Appendix 3.1).

The diversity of ecosystems, communities and habitats is also of crucial importance for ecosystem functioning. Recent experiments demonstrated the importance of habitat diversity for ecosystem multifunctionality (Alsterberg et al., 2017). Because biodiversity responds to environmental conditions and is itself driving ecosystem functioning (3.1.1), communities that are adapted to some conditions typically have high species diversity, while communities adapted to other, more stressful (e.g. Arctic), conditions have a low diversity. Global positive correlations between taxonomic diversity and temperature, evapotranspiration and other proxies of energy supply are well known (see electronic Appendix 3.1). Meta-analyses across similar communities, especially grasslands, at the global, or regional scales revealed positive, unimodal, and negative correlations between species richness and

productivity (see electronic Appendix 3.1). However, this does not contradict the positive biodiversity effect on productivity within each local community (Loreau et al., 2001; Schmid, 2002).

To maintain stable and effective ecosystem functioning in a landscape, maintaining undisturbed communities adapted to specific conditions (e.g. in peatlands, or rocky or sandy habitats) is required. Even though they typically may have lower species diversity than communities in other types of habitats, the diversity of undisturbed communities is still higher than the one of disturbed communities of the same habitat type. For example, Anderson et al. (2009) found that the distribution of carbon stocks in Britain was negatively correlated with species richness, as high carbon stocks were predominantly found in (inherently) species poor heathlands. In this case, communities typical of northern peat ecosystems, with low biodiversity, were likely most suitable for ecosystem functioning. Plant species from more diverse communities present in other habitat types are not adapted to the nutrient-poor conditions in peat ecosystems, and therefore do not function as well as the few species that are more typically found there. This case illustrates that the relevance of biodiversity for ecosystem functioning is revealed by comparisons between differently biodiverse ecosystems of the same type rather than by comparing between different types of ecosystems. Simply correlating biodiversity with ecosystem functioning across different ecosystem types ignores the fact that potential local biodiversity is not the same for all ecosystems, but depends on local environmental conditions (Schmid, 2002).

3.2.5 Long-term maintenance of multiple ecosystem functions and services

Maintaining multiple ecosystem processes at multiple places and times requires higher levels of biodiversity than does a single process at a single place and time, as shown by many studies (Byrnes et al. 2014; Cardinale et al. 2012; Hector and Bagchi 2007; Isbell et al. 2011; Maestre et al. 2012; Zavaleta et al., 2010). For example, Isbell et al. (2011) demonstrated that 84% of the 147 grassland plant species in their study, including many rare species, promoted ecosystem functioning in at least one situation. Different species promoted different types of ecosystem functions, during different years, at different places, and under different environmental contexts. These results indicate that even more species will be needed to maintain ecosystem functioning than previously suggested by studies that have considered only the number of species needed to promote one function under one set of environmental conditions.

Inclusion of ecosystem multifunctionality (i.e. the provision of multiple ecosystem functions or services) in community models shows that multifunctional redundancy is generally lower than single-function redundancy. This means that a moderate loss of species can lead to a stronger loss of ecosystem multifunctionality than of individual ecosystem functions (Gamfeldt et al., 2008). At the same time, the loss of multifunctionality due to biodiversity loss also depends on non-additive effects of biodiversity on individual functions (Gamfeldt et al., 2017).

Field studies in Europe and Central Asia confirmed an important role of biodiversity for multiple ecosystem functions (ecosystem multifunctionality) in the real world. In a study across six Western and Central European countries, van der Plas et al. (2016a) showed that at local scales, relationships between local (so-called α) tree diversity and ecosystem multifunctionality can be either positive or negative, and strongly depend on how multifunctionality is quantified. However, larger scale (so-called β) tree diversity, quantified as the differences in tree species composition among sites, positively affected spatial turnover in the types of ecosystems that were provided at high levels (β -multifunctionality) and hence landscape-scale (so-called γ -) multifunctionality, across countries,

emphasizing the scale-dependency of diversity-functioning relationships and the need for landscape-level forest diversity (van der Plas et al. 2016b) (Figure 3.5). Hence, forest management leading to biotic homogenization can have negative consequences for large-scale ecosystem multifunctionality, whereas promoting forest stands varying in tree species composition will have positive influences on large-scale forest ecosystem multifunctionality.

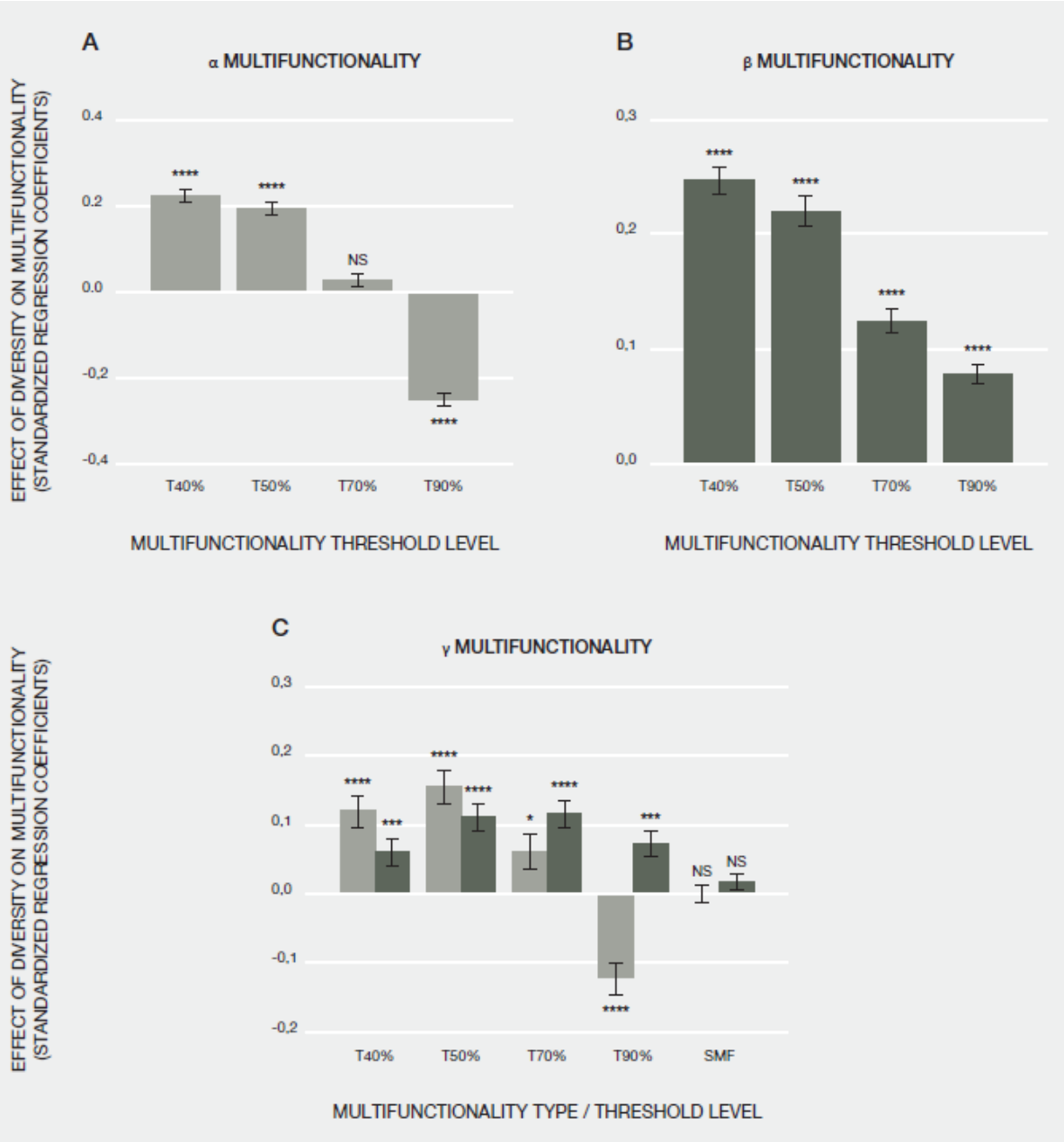


Figure 3.5: Effects of local plot-scale richness of tree species (alpha-diversity) and the turnover of tree species among plots (beta-diversity) on local (α) multifunctionality, functional turnover (β multifunctionality) and landscape-scale (γ -) multifunctionality. Copied from van der Plas et al. 2016b. Bars represent the standardized regression coefficients of α -diversity (light grey) and β -diversity (dark grey) in statistical models explaining α - (A), β - (B), or γ - (C) multifunctionality. Multifunctionality was quantified at different scales using a threshold approach, with thresholds of 40%, 50%, 70%, and 90%. In addition, sum-based γ -multifunctionality was calculated as the sum of scaled (between 0 and 1) individual function values. Diversity measures were calculated based on individuals of regionally common tree species.

A well replicated multisite study of 150 grasslands in Germany showed that plant biodiversity loss driven by land-use intensification also leads to loss of functions related to nutrient cycling, pest control, pollination and cultural services. While the effects on nutrient cycling, pest control and pollination varied among regions, effects of plant diversity loss consistently led to a loss in cultural services (Allan et al., 2015). In the same grasslands, Soliveres et al. (2016a) revealed the importance of the diversity of locally rare species (plants, invertebrates, fungi, protists and bacteria) for ecosystem multifunctionality. Locally rare above-ground species were associated with high levels of multifunctionality, while common species were only related to average, not high, levels of multifunctionality. Furthermore, Soliveres et al. (2016b) showed that not only plants are important for multiple ecosystem functions and services, but that the diversity of other trophic groups, particularly aboveground herbivores and microorganisms, is also extremely important for the maintenance of multiple ecosystem functions and services in grasslands.

Different ecosystem services profit from different types of management. Provisioning services often peak under intensive use of populations and ecosystems and at relatively low levels of biodiversity (Science for Environment Policy, 2015). Optimizing ecosystems for certain provisioning services, especially food, fibre and biofuel production has, however, greatly simplified their structure, composition and functioning across scales. While this simplification has enhanced certain provisioning services, it reduced others, particularly regulating services, and this simplification has led to major losses of biodiversity (Cardinale et al., 2012). Mapping of four provisioning services, five regulating services and one cultural service across Western and Central Europe also revealed spatial trade-offs among ecosystem services, in particular between the provisioning service of crop production and regulating services (Maes et al., 2011, 2012).

In summary, provisioning multiple ecosystem services requires maintaining and promoting high biodiversity within and between ecosystems. This implies high overall synergy between the goals of maintaining and promoting biodiversity and of maintaining and promoting multiple ecosystem services.

3.3 Past and current trends in biodiversity and ecosystems by unit of analysis

3.3.1 Introduction

Europe and Central Asia embrace a diversity of biogeographical regions from Arctic snow and ice-dominated systems in the north to Mediterranean forest and deserts in the south (Chapter 1, Section 1.3.4). The variety of the ecosystems also includes tundra, alpine and subalpine systems, temperate, boreal, tropical and subtropical dry and humid forests, peatlands, grasslands and deserts. The region also has important anthropogenic land cover types including agricultural and urban areas that are found across biogeographical regions. These categories are collectively referred to as terrestrial units of analysis, and in this section on past and current trends are addressed roughly sequentially from the north to the south of the region (Section 3.3.2), along with two examples of special ecosystems of relevance in the region, heathlands, and caves and other subterranean habitats. This is followed by a section on status and trends of biodiversity and ecosystems for inland surface waters (Section 3.3.3), which includes the categories of freshwater habitats and saline lakes. Finally, Section 3.3.4 addresses status and trends of biodiversity and ecosystems for marine systems, including the North Eastern Atlantic Ocean, Baltic Sea, Mediterranean Sea, Black and Azov Sea, Arctic Ocean, and North Western

Pacific Ocean, and the Deep Sea parts of the region and progress toward goals of Multilateral Environmental Agreements. The section is concluded by a box summarizing the trends for all terrestrial, inland surface water and marine systems in the overview **Table 3.5** and **Figure 3.43**.

3.3.2 Terrestrial Ecosystems

3.3.2.1 Snow- and ice-dominated systems

Overview of the sub-system

Glaciers and nival mountain belt

Currently glaciers are present in the high Arctic and in mountains in Europe and Central Asia. Glaciers extend for 55,800 km² in the Russian Arctic, 35,100 km² in Svalbard and 11,800 km² in Iceland. The average ice thickness varies from 280-300 m (Novaya Zemlya) to 200 m (Severnaya Zemlya) and 100 m (Franz-Joseph Land). Glaciers flowing into the sea break off forming icebergs in some coastal areas. In mountains, they extend for 25,400 km² in Scandinavia, the Alps, the Apennines and the Pyrenees, Siberia, the Caucasus, Altay, Tien Shan and Pamir (Milkov, 1977; UNEP-WGMS, 2008; Kotlyakov, 2010; AMAP, 2012; IPCC, 2013; Roshydromet, 2014; Zimnitskiy *et al.* 2015). The nival belt in mountains is characterized by extremely harsh conditions: low average annual temperature (<3.5°C) and a brief vegetation growing season (<10 days) (Korner *et al.*, 2011). In the higher mountains of the Europe and Central Asia region, “dry permafrost” in bedrock and moraines prevents the formation of continuous vegetation cover. In the northern Scandes, the lower limit for dry permafrost is currently at 1,300 m a.s.l. (Bockheim & Tarnocai, 1998).

Polar deserts

The Arctic deserts are spread over the far north of the Arctic Circle. The scant vegetation of the Arctic desert covers less than 50-60% of the soil surface, consisting of mosses, lichens, algae and a few species of higher plants (Milkov & Gwozdecky, 1969). These landscapes are common on Svalbard, Iceland, Arctic Ocean archipelagos and the Cheluskin Peninsula in Taimyr (Diakonov *et al.*, 2004; Matveeva, 2015).

The vegetation productivity here is negligible (Aleksandrova, 1983). Total biomass stock is less than 5 t/ha, dominated by above-ground biomass, thus distinguishing polar deserts from other habitats. Low vegetation productivity causes poor faunal diversity. At the extreme north of the zone only colonies of sea birds on rocky shores nest in summer and form so-called rookeries (especially on Novaya Zemlya and the Franz Joseph Land) (Milkov, 1977; Bliss *et al.*, 1981; CAFF, 2013).

Past and current trends

The glaciation of the Russian Arctic has decreased by 725 km² in area and 250 km³ in volume over the last 50 years, especially in western and central areas - 30% of it by icebergs and 70% by melting (Kotlyakov, 2010; Roshydromet, 2014). The mountain glaciers of southern Russia have decreased even more: by 40% in the Caucasus, 20% in the Altay and 30 % in the Sayan Mountains relative to the mid-20th century (UNEP-WGMS, 2008). In the Alps, glaciers lost 35% of their total area from 1850 to 1970 and almost 50% by 2000 (Zemp *et al.* 2006). The lower limit for high alpine “dry” permafrost has been escalating rapidly over recent decades (IPCC, 2014; Arctic Council, 2013).

Arctic deserts are extremely vulnerable to climate change because of greater than global average warming, decrease of ice and increase of permafrost melting in the Polar region. The warming and permafrost melting lead to more favourable conditions for plants, leading to an increase in species richness and productivity; and subsequently to the shift of vegetation type to tundra. While plant

species richness increases, some vulnerable species are affected negatively and decline (Callaghan et al., 2004; Callaghan et al., 2005; Wolf et al., 2007; IPCC, 2014; Roshydromet, 2014). At the same time better climate conditions let people use natural resources more actively (Russian Government, 2013).

Attribution of biodiversity trends to direct drivers

Glaciers play an important regulating role for reindeer in the Altay Mountains in summer, as animals spend day time on ice to avoid blood-sucking insects. Shrinking of glaciers leads to concentration of reindeer in remaining places and limits their population size (Artemov et al., 2013). The same function applies to snowbeds in the northern Scandes, where reindeer herds escape parasitic insects in warm summer days. This also allows them to see predators (e.g. wolverine) before they get close (Reimers et al., 2006).

Reduction of the period during which the sea is covered in ice, means that polar bears are forced to stay on land for longer periods of time. Studies show that a one week shift in the ice melt in spring leads to 10 kg weight loss of a bear (Morgunov, 2011). Permafrost melting also leads to erosion of landscapes and destruction of the sea shore, as previously frozen surfaces become softer and more boggy. This can sometimes result in a fast decline in the area of islands – up to 10 m per year (Roshydromet, 2014).

Pollution and mining can have dramatic local effects, including complete destruction of vegetation. However, most Arctic deserts and mountain peaks are far from main industrial human activity, and are therefore not severely affected (CAFF, 2013; Shukurov et al., 2015).

Tourism development, especially ski slopes, in high mountain ecosystems can cause their fragmentation, disturbance to animals, and land degradation in local plots (Sokratov et al., 2014).

Poaching of rare charismatic animals for illegal trading leads to a decline of their populations in Arctic deserts, especially polar bears (classified as Vulnerable A3c, Wiig et al., 2015; CAFF, 2013). The snow leopard (Vulnerable C1, McCarthy et al., 2017) is another similar example of a species affected by illegal poaching and human-wildlife conflict in high mountains (Paltsyn et al., 2012).

3.3.2.2 Tundra and Mountain Grasslands (only high elevation grasslands)

Overview of the sub-system

Tundra

Tundra refers to areas with permafrost, where the temperature is too low, precipitation too high and winds are too strong to allow for forest growth (Wielgolaski, 1972). Tundra is found on islands and on the mainland coast of the Arctic Ocean from the Kola Peninsula in the west to Chukotka in the east; and a vegetation belt in mountains from Scandinavia in the west to Kamchatka in the east and to Pamir and Tien Shan in the south (Milkov, 1977; Bliss & Matveyeva, 1992; Walker et al., 2005).

Arctic tundra is a narrow strip along the ocean coast in Iceland, on many Islands in the Arctic Ocean and from the Barents Sea to Chukotka (Walker *et al.*, 2005). There are only two layers of vegetation, grasses and mosses, with some bushes and open soil (Diakonov et al., 2004; Vasiliev et al., 1941, Aleksandrova, 1970; Bliss et al., 1981). Lichen and moss tundra is located in Iceland and in continental Eurasia, stretching in a band from the Kola Peninsula in the west to the Lena River in the east. Xerophilous and mesophilous mosses and some low shrubs are also abundant (Vasiliev et al., 1941, Aleksandrova, 1970; Bliss et al., 1981; Diakonov et al., 2004). To the south on the continent the moss and lichen tundra is replaced by shrubs, commonly consisting of dwarf birches and bush willows. The

8374 lichen-moss layer contains more grasses and forest plants (Vasiliev et al., 1941; Aleksandrova, 1970;
8375 Bliss et al., 1981).

8376

8377 Past and current trends

8378 Remote and very slow naturally recovering tundra areas were undisturbed by human impact for
8379 centuries. Currently climate change affects the tundra through global warming, opening access into
8380 the Arctic. The overall trend is towards a greater human footprint (CAFF, 2013; Russian Government,
8381 2013).

8382 The northward (and upward on mountains) range shift of species is also observed by both scientists
8383 and Arctic residents. Range shifts of plants averaging 6.1 km per decade toward the poles and 6.1 m
8384 per decade in altitude have been identified in response to a mean advancement of spring (initiation of
8385 greening) by two to three days per decade (Callaghan et al., 2005; Morgunov, 2011, CAFF, 2013; IPCC,
8386 2014).

8387 Lemming life cycles have changed in some Arctic regions probably due to changes in timing and quality
8388 of snow accumulation, with consequent impacts for lemming predators and alternative prey (Cornulier
8389 et al., 2013, Henden et al., 2010; Terraube et al., 2011; Killengreen et al., 2012; Terraube et al., 2012;
8390 Schmidt et al., 2012; Hamel et al., 2013; Millon et al., 2014).

8391

8392 Attribution of biodiversity trends to direct drivers

8393 Mechanical disturbance of the soil and vegetation cover leads to ecosystem fragmentation (Kumpula
8394 et al., 2012), formation of artificial habitats and their colonization by weeds. Off-road driving with
8395 tracked vehicles poses a problem in parts of the Arctic, especially in Eastern Europe, where impacts on
8396 tundra vegetation can persist for decades following the disturbance (CAFF, 2013). Mechanical
8397 disturbances include thermokarst induced by the thawing of permafrost; freeze-thaw processes; wind,
8398 sand, and ice blasts; seasonal ice oscillations; slope processes; snow load; flooding during thaw;
8399 changes in river volume; coastal erosion and flooding. Biological disturbances include insect-pest
8400 outbreaks, peaks of grazing animals that have cyclic populations, and fire (Callaghan et al., 2005).
8401 Overgrazing by domestic reindeer causes destruction of vegetation cover (Morgunov, 2011; Aleynikov
8402 et al., 2014), - a widespread direct human-induced pressure on terrestrial Arctic in Europe and Central
8403 Asia (CAFF, 2013).

8404 The Arctic stands out in terms of climate change effects on biodiversity (Callaghan et al., 2005),
8405 including a prolongation of the growing season and an increase in productivity (for plants), nesting
8406 period (for birds), and warm season (for invertebrates). Climate change has led to a northward shift of
8407 the tundra-forest boundary; the extension of some species ranges, changing migration patterns; and
8408 to the introduction of alien species. An increase in the frequency of climatic anomalies such as winter
8409 thaw, summer frosts, increased precipitation, including snow, leads to the mass deaths of animals (e.g.
8410 reindeer and waterfowl) (Bhatt et al., 2010; CAFF, 2013; Gauthier et al., 2013; Hudson & Henry, 2009;
8411 IPCC, 2014 (Part A & B); Morgunov, 2011; Reynolds et al., 2006; Xu et al., 2013).

8412 Poaching and unregulated use of biological resources affect rare and vulnerable species. Polar bear
8413 poaching in Eastern Russian coastal tundra estimated at 100-200 animals per year (Kochnev, 2004;
8414 Morgunov, 2011; Kochnev & Zdor, 2014). While gathering goose down or hunting for birds and animals
8415 for food, local people may be unaware of the species national conservation status (Красная книга
8416 Российской Федерации, 2001; Lavrinenko & Lavrinenko, 2006) and protection by law (Aleynikov et
8417 al., 2014).

8418 Intentional and unintentional introduction of alien species in Arctic ecosystems is ongoing. Fifteen
 8419 alien invertebrate species, for example, have settled in Svalbard, many of them introduced via
 8420 imported soils (Coulson, 2015).

8421 Pollution by oil spills, mining or toxic waste dumps can transform or destroy vegetation cover and
 8422 animal populations (Kumpula et al., 2011; Virtanen et al., 2002). Persistent organic pollutants and
 8423 heavy metals accumulate in Arctic ecosystems, despite being produced and released in temperate and
 8424 tropical regions, due to global atmospheric circulation (CAFF, 2013).

8425

8426 ***Subalpine and Alpine ecosystems***

8427 The alpine mountain belt is situated above subalpine and below snow and ice dominated ecosystems.
 8428 The alpine vegetation comprises mainly perennial grasses, sedges, forbs, prostrate shrubs, cushions,
 8429 tussocks, bryophytes and lichens (Körner, 2003; Körner et al., 2011). It demonstrates high rates of local
 8430 endemism (Grabherr et al., 1995). Mountain tundra (as a variant of the alpine type) is most developed
 8431 in Eastern Siberia, but can be found in all high mountains in Eurasia from the Urals to Kamchatka and
 8432 from the Arctic to Tien Shan (Vasiliev et al., 1941; Aleksandrova, 1970). Central Asian mountains
 8433 contain a very specific variation of the alpine belt in extremely dry climate – alpine deserts in Pamir
 8434 (Breckle & Wucherer, 2006).

8435 The subalpine mountain belt is an ecotone zone between forest or steppe and alpine vegetation belts.
 8436 It occurs at elevations from the sea level in the Kurily Islands in the Pacific Ocean up to 1,700-2,300 m
 8437 in the Alps, Caucasus and Mediterranean mountains. The four main types of ecosystems in the
 8438 subalpine belt are high-grass subalpine meadows; communities of dwarf bushes and shrubs;
 8439 heathlands and grasslands consisting of short grasses; and subalpine thinned park type and crooked
 8440 forests (Malyshev & Nimis, 1997).

8441 Alpine and subalpine ecosystems stand out for their extremely high biodiversity. 20% percent (approx
 8442 2,500 species) of Europe's vascular plant flora were estimated to being predominantly alpine, i.e.
 8443 occurring within only 3% of the continent's territory (Grabherr et al., 1995; Väre et al., 2003).
 8444 Mountains around the Mediterranean basin, such as Sierra Nevada in Spain, are outstandingly rich in
 8445 local endemic species (Pauli et al., 2003) and there is a general south-to-north gradient of decreasing
 8446 endemism in mountains across Europe (Favarger, 1972). The subalpine belt is especially diverse in
 8447 mountains of Europe and Central Asia and includes a large part of endemic species. For example, in
 8448 Central Asian mountains more than 600 species of vascular plants were found and 50 of them are
 8449 endemics (Shukurov et al., 2015; Kovalevskaya et al., 1968-1993), in the Central Caucasus mountains
 8450 the endemism level is higher: 197 from 595 species (Nakhutsrishvili, 2003).

8451

8452 Past and current trends

8453 The subalpine ecosystems in Europe and the Caucasus are strongly modified through a long history of
 8454 human use. Humans converted large parts of subalpine woodlands into pastures and hay meadows,
 8455 which resulted in a widespread increase in secondary grasslands below the tree line. The actual tree
 8456 lines have shifted downwards especially in densely populated mountains such as the Alps and the
 8457 Caucasus (Körner, 2003; 2012). Unlike in the Alps, in southern Siberia the altitudinal range of the
 8458 subalpine belt is mostly conditioned by natural factors (Malyshev & Nimis, 1997).

8459 In the Carpathians the subalpine scrub communities almost completely disappeared, being
 8460 transformed into so-called polonina with matgrass (*Nardus stricta*) swards or communities dominated
 8461 by blueberry (*Vaccinium myrtillus*) with very low plant diversity (Kricsfalussy et al., 2008). Overgrazing
 8462 in Tien-Shan in the second half of the 20th century was five to ten times over the tolerance limit

(Shukurov, 2007). Pamir alpine deserts are 20% moderately degraded, 25% strongly degraded and 55% extremely degraded (Breckle & Wucherer, 2006). As a result, wild species were crowded out by livestock and their number has dramatically declined (Korotenko & Domashov, 2014). This subsequently led to a decline in the number of predators and scavengers (Shukurov, 2007).

Attribution of biodiversity trends to direct drivers

Mountain meadows in Europe and Caucasus suffer from overgrazing, which leads to simplifying of ecosystem structure and decline of population abundance and species richness (European Union, 2016).

Alpine grasslands today undergo rapid transition driven by changes in land use and climate. Thermophilous species increased while cold-adapted high-elevation species declined in European mountains (Gottfried et al., 2012; Grabherr et al., 2010; Malanson et al., 2011). Upward altitudinal shifts of alpine plant species ranges have repeatedly been observed in mountains (Klanderud & Birks, 2003; Kokorin et al., 2011; Pauli et al., 2012; Wipf et al., 2013), which has led to increased species numbers on mountain tops in northern parts of Europe, but to declines in Mediterranean mountains (Jiménez-Alfaro et al., 2014; Pauli et al., 2012). The rate of tree line change varies across the region, usually several meters per decade and more than 100 m in Sweden and Norway (IPCC, 2014).

Species population dynamics may lag behind climatic changes due to the persistence of some alpine plant species (Dullinger et al., 2012). Abandonment of traditional farming and rural depopulation has become an evident trend in European and Caucasus mountains (Keenleyside et al., 2010). The consequence is natural reforestation (Gehrig-Fasel et al., 2008; Sitzia et al., 2010), which reduces landscape heterogeneity, increases fire risks and exacerbates human-wildlife conflicts (Körner, 2003; Navarro & Pereira, 2015; Wilson et al., 2012).

Landscape fragmentation and degradation as a result of the development of ski and tourism centres in high mountains have local negative impacts on biodiversity, species decline (especially rare and endemic species) and homogenization. Disturbance of vegetation on steep slopes may result in mudslides and water erosion (Belonovskaya, 1995; Akatov et al., 2003). In Kyrgyzstan mining in high mountain ecosystems has led to degradation, fragmentation and pollution of vulnerable subalpine and alpine grasslands (Korotenko & Domashov, 2014; Shukurov, 2007).

Often changes are due to combinations of drivers. For example, species richness in Scottish alpine areas over a 20–40 year period increased in most habitats, while β -diversity declined, resulting in increased homogeneity of vegetation. Key northern and alpine species declined, while lowland generalist species increased. This change was consistent with impacts of climate change, but other elements of spatial pattern (decline in lichen richness in high deposition areas) were consistent with effects of nitrogen pollution (Britton et al., 2009), which transforms species composition significantly (Bassin et al., 2007).

3.3.2.3 Temperate and boreal forests and woodlands

Overview of the sub-system

Broad-leaved, mixed and coniferous forests constitute most of the potential natural vegetation in about 80% of Europe (Bohn et al., 2000) and Central Asia. Other patchily distributed forest types include water-influenced forests like black alder carrs and ravine forests on steep slopes. The vast area of boreal forest includes much of Fennoscandia, the middle and northern part of European Russia, Southern Siberia and far eastern part of Russia, covering ca 809 million ha (Federal Forestry Agency of Russian Federation, 2013).

8508

8509 Past and current trends

8510 The main past and current trends in biodiversity have been deforestation and fragmentation. In

8511 Western and Central Europe, conversion of deciduous forest to agriculture caused large breaks in

8512 connectivity and loss of the typical plant communities. Recovery of ecosystems lags far behind the

8513 efforts made in afforestation in these predominantly agricultural landscapes (Hermy et al., 1999).

8514 High biodiversity of various taxa of forest ecosystems is associated with natural disturbances like fires,

8515 wind and insect outbreaks, creating patches of dead trees and heterogeneity at different spatial scales.

8516 Up to 4,000 species are dependent on coarse woody debris as habitat (Stokland, Siitonen, & Jonsson,

8517 2012). Protected areas focus on limiting human intervention in forests, with the aim of conserving

8518 species dependent on forest cover continuity, deadwood and large trees. Many bryophytes, lichens,

8519 fungi, vascular plants, saproxylic beetles and birds and cavity-nesters are associated with old forests

8520 (Bilz, Kell, Maxted, & Lansdown, 2011; Moning & Müller, 2009; Paillet et al., 2010; Roberge et al., 2015;

8521 Gregory et al., 2007; Scheidegger, Bilovitz, Werth, Widmer, & Mayrhofer, 2012; Virkkala, Heikkinen,

8522 Leikola, & Luoto, 2008).

8523 In the 18th century modern forestry began to reduce traditional forest pasturage, litter raking, charcoal

8524 making, pollarding and coppicing (Szabó, 2013). This replacement to high forests led to loss of species

8525 like threatened butterfly species associated with these open habitats (Konvicka, Fric, & Benes, 2006).

8526 These changes have shifted the composition of understorey towards more shade-tolerant and

8527 nutrient-demanding species (de Frenne et al. 2013, Kopecký, Hédli, & Szabó, 2013) and forest

8528 vegetation has undergone significant loss of plant specialists (see e.g. De Frenne et al. (2013); Keith,

8529 Newton, Morecroft, Bealey, & Bullock (2009)), loss of lichens (Reinecke, Klemm, & Heinken, 2014) and

8530 decreased multi-functionality at landscape-scale (van der Plas et al., 2016a). This process is visible also

8531 in some coniferous forests (Hedwall & Brunet, 2016). Traditionally managed open forest habitats

8532 included in European Union protected habitats currently have unfavourable status (Bastrup-Birk,

8533 Reker, & Zal, 2016).

8534 For the 2007–2012 period, the 27 European Union member States reported that only 26% of forest

8535 species and 15% of (non-Mediterranean) forest habitats (29 habitats) of European interest, as listed in

8536 the European Union's Habitats Directive, are in favourable conservation status (EEA, 2015). An

8537 additional 7 have unfavourable but improving status with respect to the 2001-2006 period, 54 are

8538 deteriorating, 102 are stable or have unknown trends. In Central Europe, 248 assessments were

8539 performed (combinations of habitats and countries) and of these 56 were favourable, 16 unfavourable

8540 but improving, 46 unfavourable and declining, 123 unfavourable but stable, and 7 had unknown or

8541 unreported status and trends. In Western Europe, 380 status and trend assessments were performed,

8542 of which 66 were favourable, 25 unfavourable but improving, 83 unfavourable and declining, 125

8543 unfavourable stable and 81 unknown or unreported. The most endangered habitats are forests along

8544 rivers and on bogs and water-influenced habitats such as ravine and boreal coniferous forests, riparian

8545 alluvial forests, lichen Scots pine forests, old acidophilous oak woods on sandy plain, Fennoscandian

8546 wooded pastures and swampy forests (Janssen et al., 2016).

8547 For people in remote forested areas, old-growth mountain or boreal forests are the only source of

8548 wood, and a source of food. Planted forests exclusively used for timber cover about 10% of the

8549 European Union (EEA, 2016). Throughout the forests of Europe and Central Asia, biodiversity is an

8550 important source of non-wood products (berries, mushrooms, game animals and recreation).

8551 Mustonen & Helander (2004) reported a decline of certain berry plants such as marsh whortleberries,

8552 traditionally collected by the Sami people in Finland.

A significant upward shift in the optimal elevation of forest herb and woody species occurred during the 20th century in various Western, Central and Eastern European forests, including primary forests (Engler et al., 2011; Lenoir, Gégout, Marquet, de Ruffray, & Brisse, 2008; Šebesta et al., 2011). Across several regions, the upper elevational limits of both tree seedlings and saplings were significantly higher than of adults (e.g. Vitasse et al., 2012). However, despite the observed climate change, tree distribution of life-stage has not changed directionally (Máliš et al., 2016). Drought is also known to be increasing fire risk in boreal forest (Drobyshev, Niklasson, & Linderholm, 2012) which, coupled with inadvertently human-caused ignition, can cause extensive wildfires.

Attribution of biodiversity trends to direct drivers

Direct drivers such as the expansion of infrastructure (urban and transport), unsustainable silviculture (including alteration and embankment of streams and spring drainages, excessive use of chemicals and clear-cutting and afforestation by monocultures of invasive species), conversion to agricultural land use and the lack of natural processes (e.g. floods in floodplain forests or fires in taiga forests) have affected forest ecosystems (Forest Europe, 2015) (**Figure 3.6**).

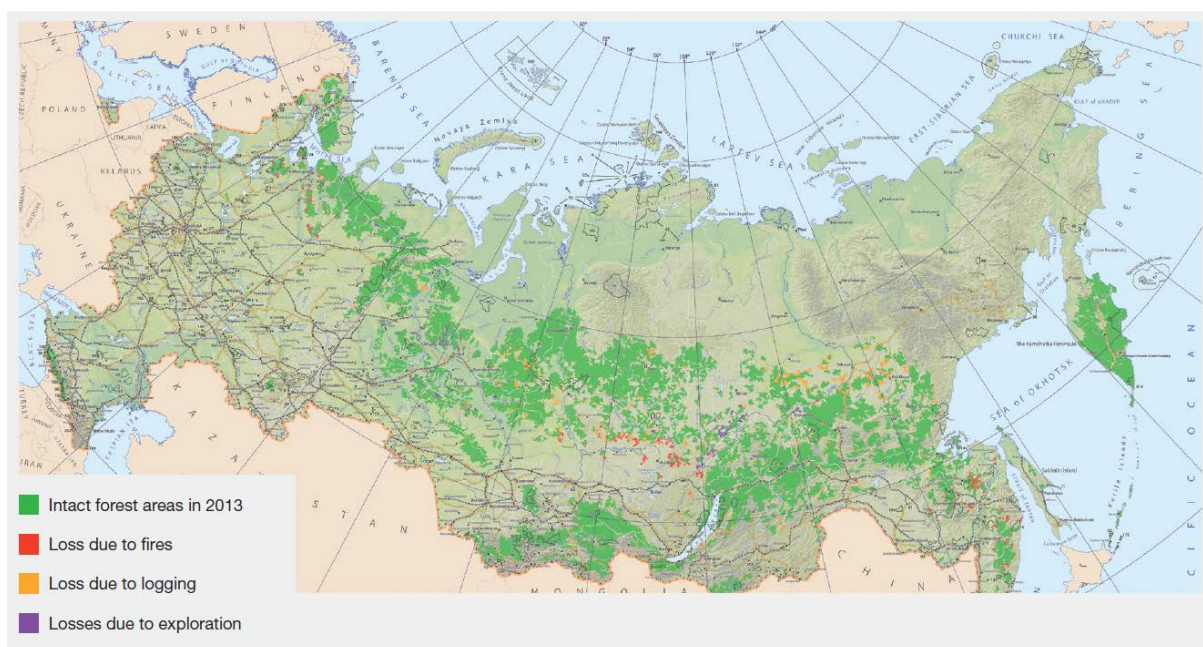


Figure 3.6: State and loss of intact forests in Russia in 2002–2015. WWF, 2015.

It is difficult to disentangle the influence of various drivers on forest indicators; however, repeated surveys (see e.g. initiative www.forestreplot.ugent.be) have revealed significant changes in species composition and distribution ranges.

In Central and Western Europe there have been trends of increasing integrated forest management for conservation of biological diversity by close-to-nature forest management without clear cuts to increase continuity of forest structures, and emulation of natural disturbances (creation of dead wood and natural rejuvenation (Kraus & Krumm, 2013). Large populations of game animals can decimate natural rejuvenation by browsing (Kuijper et al., 2010) or rooting (Brunet, Hedwall, Holmström, & Wahlgren, 2016).

In addition, the current large tree plantations are prone to invasions by species in the forest understorey (Essl, Moser, Dullinger, Mang, & Hulme, 2010; Pyšek, Křivánek, & Jarošík, 2009). Among

the problematic invasive alien species, 33 (invertebrates, vascular plants and fungi) are regularly found in European Union forest ecosystems or are dependent on trees (EEA, 2016).

Past deposition of SO₂ caused acidification of soil in some areas (Krám et al. 2012), resulting in the widespread dieback of Norway spruce plantations and mountainous coniferous forests and associated decline of ectomycorrhizal fungi in the 1980s (Arnolds, 1991). Current atmospheric nitrogen deposition in areas of Central and Western Europe has caused soil eutrophication (Hédli, Petřík, & Boublík, 2011, Lomský, Šrámek, & Novotný, 2012, Šebesta et al., 2011), in general and locally close to urban and industrial areas (“National Atlas of Russia,” 2000). This has caused changes in forest plant communities (Ewald et al., 2013; Verheyen et al., 2012).

3.3.2.4 *Mediterranean forests, woodland and scrub*

Overview of the sub-system

This unit stretches west to east from Portugal to Jordan, includes ecosystems on Madeira, the Azores and Canary Islands in the Atlantic Ocean (Conservation International, 2011; FAO, 2013) and is characterized by cool wet winters and dry hot summers causing water stress (Allen, 2014; Gauquelin et al., 2016). Similar conditions can be found in the Crimean Peninsula, Turkey, and in lower parts of the Caucasus and Central Asian Mountains, which are sometimes also considered as a part of the Mediterranean area (Takhtazhyan, 1978; Sekercioglu et al., 2011). Further to the east, juniper and pistachio woodlands and scrub become the most common ecosystems (Fayvush, Aleksanyan, 2016; Şekercioglu et al. 2011, Tajikistan NBSAP, 2016; Turkmenistan Fifth National Report, 2015). In Central Asia, they are composed of pistachio-almond dry woodlands (Venglovsky, 2006).

The Mediterranean area is among the world’s richest places in terms of plant diversity, with 25,000 plant species, 50% of them endemic (Blondel et al., 2010). There are 290 tree species (Noce et al., 2016), of which 200 are endemic (Quézel & Médail, 2003; Gauquelin et al., 2016). Two thirds of Mediterranean amphibian species, 48% of reptiles, a quarter of mammals, 14% of dragonflies, and 3% of birds are endemic (Mittermeier et al. 2004; Paine & Lieutier, 2016; Lefevre & Fady, 2016; FAO, 2013). With 52 plant refuges during ice ages (Médail & Diadema, 2009), the Mediterranean is recognized as a Global Biodiversity Hotspot (Mittermeier et al., 2004).

In scrublands, the dominant maquis has many local names reflecting indigenous and local knowledge, such as matorral in Spain, phryganae in Greece or bartha in Israel. It is characterized by hard-leaved shrubby evergreen species of genera *Cistus*, *Erica*, *Genista*, *Juniperus*, *Myrtus*, *Phillyrea*, and *Pistacia*. The term “garrigue” is restricted to the limestone, semi-arid, lowland and coastal regions of the basin and is maintained by grazing and fires.

Past and current trends

The State of Nature in the European Union reports that 139 habitats were assessed for the Mediterranean Ecoregion in the European Union. In the period 2007-2012, 27 of these were of favourable conservation status, 1 is unfavourable but improving with respect to the 2001-2006 period, 49 are deteriorating, 62 are stable or have unknown trends. In Central Europe, 38 assessments were performed (combinations of habitats and countries) and of these 37 were favourable and one unfavourable but stable. In Western Europe, 467 assessments were performed, of which 139 were favourable, 6 were unfavourable but improving, 104 unfavourable and declining, 107 unfavourable stable and 109 unknown or unreported status and trends (EEA, 2015).

Originally, the Mediterranean region was largely covered by evergreen oak forests, deciduous, semi-deciduous, and conifer (pine, juniper) forests (De Beaulieu et al., 2005). However, as a result of

centuries of deforestation, no intact forest is left in the region (Blondel et al., 2010; CEPF, 2010). Both human intervention and climatic conditions are favouring the development of shrublands and then of sclerophyllous and secondary coniferous forests, replacing the primary semi-deciduous and deciduous forests (Abdurakhmanov et al., 2003; Blondel et al., 2010; CEPF, 2010; Allen, 2014). UNEP, FAO and UNFF (2009) reported that 67% of the sub-system of the Mediterranean forest, woodland and scrub had been converted before 1950, whereas recent changes only represent 3% in terms of area. During the 1990-2005 period the area covered by forest generally increased except in Croatia and Bosnia-Herzegovina (UNEP, FAO & UNFF, 2009; FAO, 2013). Plantations cover about 11% of the area, mostly formed by pines and eucalyptus (Wingfield et al., 2015; de Rigo et al., 2016).

Attribution of biodiversity trends to direct drivers

Mediterranean forests are the product of a long history of agro-sylvo-pastoral management by rural populations and of interactions between local societies and the state (mainly through the public forest administration) (Blondel 2006; Gauquelin et al., 2016; Kouba et al., 2015; Lefevre and Fady, 2016; Paine & Lieutier, 2016; Médail & Diadema, 2009). At low altitudes, the present Mediterranean forests have been managed by coppicing, wood cutting, prescribed fires and grazing, while at higher altitudes they have been conserved (Blondel et al., 2010). Fires and herding are particularly important drivers of vegetation dynamics and selection of plant traits (Arianoutsou, 2001; CEPF, 2010; de Rigo et al., 2016). After the Second World War, land abandonment resulted in land cover changes from pastures to scrub and later to closed forests, and was accompanied by significant changes in biodiversity (Gauquelin et al., 2016; Lavergne et al., 2005; Mazzoleni et al., 2004; Sirami et al., 2010). The most important threats for Mediterranean woodland species are habitat loss, fragmentation, land degradation and anthropogenic fires causing primary forest cover to decrease and an increase of secondary forest and shrubland (Abdurakhmanov et al., 2003; Penuelas et al., 2002; FAO, 2013; Armenia's Third National Communication, 2015; EEA, 2002). Nitrogen pollution from agriculture, (Sutton et al., 2014; Feest et al., 2014), and unsustainable harvesting and hunting (Penuelas et al. 2002; IUCN, 2008; FAO, 2013) also contribute to biodiversity loss.

Climate change, with an increase in temperature and frequency of natural disasters, especially droughts, leads to aridification, desertification and a decline of species richness (Allen, 2014; FAO, 2013; IPCC, 2014).

With the exception of some pyrophytic species like *Cistus* sp. (EEA report, 2004), pine woodlands are more sensitive than shrubland and oak forest to more frequent wildfires (Pausas et al., 2008; Moreira et al., 2011; Dias et al., 2016).

Invasive alien species, including forest pests and diseases (potentially favoured by fires) and plantations of exotic tree species also contribute to biodiversity loss (de Rigo et al., 2016; EEA report, 2004; IUCN, 2008). Eucalyptus monocultures can be infected with up to 150 pathogens, spreading more easily in uniform conditions (de Rigo et al., 2016; Wingfield et al., 2015), while pine invasion promotes soil acidification, causing a decrease of taxonomic and phylogenetic diversity (Selvi et al., 2016).

3.3.2.5 Tropical and subtropical dry and humid forests

Overview of the sub-system

There are several types of laurel subtropical forests ("laurifolia" or "laurisilva") on islands in the North Atlantic Ocean, belonging to the Macaronesian biogeographical province. They occupy territories with medium to high precipitation of Azores, Canary Islands and Madeira islands between altitudes of 600

8671 and 1500 m (Dias et al., 2005; Fernandez-Palacios & Arevalo, 1998) and demonstrate a high species
8672 diversity: 12,660 species of fungi, plants and animals with extremely high level of endemism – 30%
8673 (3,570 species) (Moya et al., 2004).

8674 Two types of mixed and deciduous humid subtropical forests with evergreen elements grow in the
8675 Caucasus Mountains: Colchic in the west (Georgia, Russia and Turkey) and Hyrcanic in the east in
8676 Azerbaijan (Akhani et al., 2010; Chitanava, 2007; Grossheim, 1926; Physico-Geographical Atlas of the
8677 World, 1964; Prilipko, 1970; Safarov, 1979; Safarov, 2009; Solomon et al. 2014). Other researchers
8678 consider Colchic and Hyrcanic forests as specific temperate rainforests, rather than subtropical,
8679 because of the mild climate conditions with cooler winters than in many subtropical regions and the
8680 presence of the sclerophyllous species only in undergrowth and absent from the tree layer (Borsch et
8681 al., 2014; Maharramova et al., 2015; Nakhutsrishvili et al., 2015; Zazanashvili & Mallon, 2009). Colchic
8682 forests include about 3,600 vascular plant species, and Hyrcanic forests more than above 1,200 species
8683 (Abdurakhmanov et al. 2003; Akhani et al. 2010; Chitanava, 2007; Filibeck et al. 2004; Grossheim, 1926;
8684 Physico-Geographical Atlas of the World, 1964; Prilipko, 1970; Safarov, 1979, 2009; Solomon et al.
8685 2014; Tutayuk, 1975; **Figure 3.7**). Twenty to 30% of Caucasian flowering plants, fish, and terrestrial
8686 vertebrates and invertebrates are endemic. Endemism in terrestrial molluscs can reach 75% (CEPF,
8687 2004; Mumladze et al., 2008; Nakhutsrishvili et al., 2015; Zazanashvili & Mallon, 2009). Due to the high
8688 diversity of relict Arcto-Tertiary species (Gegechkori, 2011) and the high level of endemism these
8689 forests are included in the Caucasus Global Biodiversity Hotspot (CEPF, 2010; Mittermeier et al., 2004),
8690 the Western Caucasus UNESCO World Heritage Site (Succow & Uppenbrink, 2009) and Global 200
8691 WWF ecoregions (WWF, 2006).

8692 Tugai is a type of gallery forest and shrubland interspersed with grasslands along the Caucasus and
8693 Central Asian rivers, similar to natural riparian forests in the northern part of Europe and Central Asia
8694 (Glazovsky, 1990; Sadygov, 2012; Shukurov, 2009). Primary wild walnut-fruit forests and woodlands
8695 are a specific feature of Central Asian mountains and relict ecosystems, remaining as refuges during
8696 ice ages. They occupy mountain slopes at 800 - 2100 m a.s.l. (Janick, 2003; Shukurov et al., 2005;
8697 Venglovsky, 2006).



Figure 3.7: Location of Colchic and Hyrcanian forest areas (Nakhutsrishvili et al. 2015)

Past and current trends

Subtropical forests have been transformed by human activities. Currently, native subtropical forests in Europe and Central Asia occupy only 20% of initial laurel forest area (Fernandez-Palacios & Arevalo, 1998) and about 10% of Colchic, Hyrcanian, Amu Darya and Azerbaijan Tugai forest area. Mostly they have been transformed into agricultural lands. Remaining subtropical forests are fragmented and degraded because of logging and overgrazing, or replaced by Mediterranean type vegetation. This has been the case with laurel forests in Macaronesia and Tugais in Armenia (Azerbaijan Republic, 2014; Bikirov, 2012; Burkhanov, 2013; Fayvush & Aleksanyan, 2016; Fernandez-Palacios & Arevalo, 1998; Ionov & Lebedeva, 2004; Janick, 2003; Jungius, 2012; Mumladze et al., 2008; Nakhutsrishvili et al. 2011; Shukurov et al., 2015; Treshkin, 2001; Turdieva et al., 2007; Yusifov & Hajiyeve, 2004; Zazanashvili & Mallon, 2009). 97% of Macaronesian Laurisilva is in Madeira, and is in unfavourable but stable conservation status, the remaining 3% is in the Canary Islands and is considered in favourable conservation status (EEA, 2015).

The total number of regional extinctions from subtropical forest is unknown. However, noteworthy is the global extinction of the Caspian tiger (*Panthera tigris* ssp. *virgata*). About 50% of natural Azorean species are in danger of extinction (Dias et al., 2005). Twenty-one species of mammals, birds, reptiles and amphibians in Caucasus forests are globally threatened and included in IUCN Red Lists as vulnerable, endangered or critically endangered. Of these, 8 are endemic (West Caucasian tur (*Capra caucasica*), Clarks' lizard (*Darevskia clarkorum*), Charnali lizard (*Darevskia dryada*), large-headed water snake (*Natrix megalcephala*), Caucasian viper (*Vipera kaznakovi*), Black Sea viper (*Vipera pontica*), Caucasian salamander (*Mertensiella caucasica*) and Persian mountain salamander (*Iranodon persicus*)

8722 (Nakhutsrishvili *et al.* 2011). The population of Bukhara deer declined to 100 animals in Tajikistan
8723 (Bannikov & Zhirnov, 1971; Jungius, 2012).

8724

8725 Attribution of biodiversity trends to direct drivers

8726 Overgrazing affects all types of remaining subtropical forests, but especially damaged wild walnut-fruit
8727 forests in Central Asia because of the lack of good pastures. So far, numbers of livestock (mainly goats
8728 and sheep) have been growing. Only in Kyrgyzstan in walnut-fruit forests it increased by 5% from 2012
8729 to 2013 (Asykulov & Chodonova, 2015). This leads to structural homogenization, extinction of rare and
8730 endemic species, and introduction of weeds and invasive species like Japanese spiraea (*Spiraea*
8731 *japonica*) (Nakhutsrishvili *et al.*, 2011; Treshkin *et al.*, 1998; Shukurov *et al.*, 2005; Fernandez-Palacios
8732 & Arevalo, 1998; Prada *et al.*, 2009; Asykulov & Chodonova, 2015).

8733 In Macaronesia tourism exerts pressure on ecosystems through recreational activities, disturbance of
8734 species, and risk of fires and wastes. From 1960 to 1998 the number of tourists increased from 940,000
8735 to 12.5 million people each year, 6 times as large as the local population. The resulting anthropogenic
8736 pressure impairs natural ecosystem functioning (European Commission, 2014; Fernandez-Palacios &
8737 Arevalo, 1998).

8738 In Azerbaijan water storage facilities have transformed the water regime downstream the Kura River,
8739 making it drier and without regular floods. These conditions are unsuitable for Tugai forest (Sadygov,
8740 2012).

8741 Aridification caused by global warming negatively affects Hyrcanian and walnut-fruit forests - dryer
8742 forest types (IPCC, 2014) and they lose mesophytes (Program and Action Plan, 2015). Increasingly, the
8743 frequency of catastrophic floods and forest fires caused by climate change, cause the decline of
8744 species richness in all subtropical forests within Europe and Central Asia (Prada *et al.*, 2009; Succow
8745 & Uppenbrink, 2009; Zazanashvili & Mallon, 2009).

8746 Invasive species affect all types of subtropical forests (Fernandez-Palacios & Arevalo, 1998; Shukurov,
8747 2016). The Azorean flora consists of 1,007 plants species, 707 of which have been introduced mostly
8748 in the last fifty years (Dias *et al.*, 2005). An invasion of box tree moth (*Cydalis perspectalis*) in 2012
8749 in the Caucasus exemplifies the magnitude of pest damage in the region. It has developed in an active
8750 pest outbreak in 2013, and expanded from common box (*Buxus sempervirens*) into an endemic relict
8751 box (*Buxus colchica*) in the wild (Gninenko *et al.*, 2014). In 2015 it reached Abkhazia and Crimea, and
8752 has destroyed most *Buxus colchica* in the Caucasus Colchic forests (Abasov *et al.*, 2016). Pest outbreak
8753 effects have been exacerbated by destabilisation of ecosystems due to pesticide application (Shukurov,
8754 2016). Pollution from agricultural sources has caused a strong decrease in the area covered by
8755 subtropical forest ecosystems (Kuz'mina & Treshkin, 1997; Shukurov *et al.*, 2005; Zazanashvili &
8756 Mallon, 2009).

8757 In Central Asia, mining projects have been developed in walnut-fruit forests, polluting air and water
8758 and leading to the degradation of the forest vegetation (Janick, 2003).

8759 After the collapse of the Soviet Union many fields and plantations were abandoned and a process of
8760 natural reforestation started (Nakhutsrishvili *et al.* 2011). Today these are gradually being returned to
8761 agriculture, thereby preventing the expansion of subtropical ecosystems in this way (Shukurov *et al.*,
8762 2015).

8763 Countries have recognized the necessity to conserve the remaining subtropical forests and species and
8764 to establish protected areas (Turdieva *et al.*, 2007; The Kyrgyz Republic, 2014; Safarov *et al.*, 2014;
8765 Turkmenistan Fifth National Report, 2015; Ministry of Environment and Water Resources of the
8766 Republic of Kazakhstan, 2015; Sadikov *et al.*, 2015). For example, all remaining laurel forests in the

Canary Islands are protected (Fernandez-Palacios & Arevalo, 1998), and 37% of Hyrcanian forests in Europe and Central Asia are covered by protected areas (Nakhutsrishvili et al., 2015). Programmes on forest restoration have started in some countries (ENPI-FLEG, 2015), to promote the recovery of species diversity and habitat. Due to implemented measures, populations of some threatened species have become stable or even slowly growing, such as Bukhara deer in Kazakhstan (Greifswald, 2010; Ministry of Environment and Water Resources of the Republic of Kazakhstan, 2015; Republic of Turkey, 2014; Sadikov et al., 2015; Safarov et al., 2014; The Kyrgyz Republic, 2014; The Republic of Tajikistan, 2016; Turkmenistan Fifth National Report, 2015).

3.3.2.6 Temperate grasslands

Overview of the sub-system

The ecosystem comprises dry or seasonally wet (not overwetting) non-coastal land, more than 30% covered by natural vegetation. Vegetation is dominated by herbaceous, shrub plants and trees. Actively managed grasslands and cultivated lands, high-mountainous (alpine) grasslands, and arid dwarf-shrublands (semi-deserts) are covered in 3.2.2.9, 3.3.2.2. and 3.3.2.7, respectively. Three main grassland types are distinguished in Europe and Central Asia (namely: Steppes, azonal/extrazonal natural dry grasslands, and secondary (semi-natural) grasslands (Bohn et al., 2004; Dengler et al., 2013; Dengler et al., 2014; Ellenberg & Leuschner, 2010; Veen et al., 2009; Vrahnakis et al., 2013; Wesche et al., 2016). The natural grasslands of the two first types are essentially self-sustaining if the wild herbivore assemblage is present or replaced with a domestic one. The man-made grasslands of the last type require continuous management to preserve their current status (or restore them). The area of original extent of steppes in Europe and Central Asia was assessed as 1,700,000km². The actually remaining steppe area was assessed as 670,000 km² (Henwood 2010).

Europe and Central Asia's grasslands are global hotspots of small-scale (at scales below 100 m²) vascular plant diversity. Some prominent examples are Transylvanian and Carpathian dry meadows (or meadow steppes) where up to 98 vascular plant species can co-exist on 10 m² and 133 species on 100 m² (Dengler et al., 2014; Török et al., 2016; Wilson et al., 2012); . This richness may result from the traditional management practices of local people (Babai & Molnár, 2014). More than 18 % of Europe's endemic vascular plants are bound to grassland habitats (Habel et al., 2013; Hobohm & Bruchmann, 2009).

Europe and Central Asia's grasslands provide important habitats for many species of global conservation concern, such as the saiga antelope (*Saiga tatarica*), great bustard (*Otis tarda tarda*), sociable sparrow (*Vanellus gregarius*) (IUCN, 2017b). In Europe, the birds associated with grasslands (and low intensity agricultural) habitats have the highest proportion of threatened species (23%) compared with other habitats (BirdLife International, 2015b).

The steppe habitats of Russia harbour 11 mammal species of global conservation concern. The Federal Red Data Book of Russia listed 14 mammal and 14 bird species strongly linked to steppe habitats (two are extinct in the wild in Russia) (Antonchikov, 2005; Smelansky & Tishkov, 2012), and 30 insect species inhabiting only grasslands (presumably steppes) comprising 31 % of the whole list of insects (94 taxa) (*Red Data Book of Russian Federation*, 2001)). In Ukraine (Parnikoza & Vasiluk, 2011; Vasiluk et al., 2010) steppe animals comprise 29% of the list of the national Red Data Book (159 from 553). Among 826 species of plants listed in the Red Data Book of Ukraine 33.4% (276) can be found in steppe habitats only (Korotchenko & Peregrym, 2012; Parnikoza & Vasiluk, 2011).

European grasslands have been recognized as threatened hotspots of biodiversity which emphasizes their high conservation priority (Dengler et al., 2014; Habel et al., 2013; Török et al., 2016). Fifty three grassland habitats, distinguished in Europe, are assessed as threatened to some degree, including 12 Critically Endangered or Endangered habitats (Janssen et al., 2016). Nearly half of the bird species associated with grasslands have a threatened population status in the European Union (EEA, 2015f).

In the steppes of Russia only 10% of the protected areas are covered by grasslands (Tishkov, 2005); only 11 of 151 Russian federal strict nature reserves and national parks conserve significant steppe tracts and they comprise only ca. 1% of the total area of federal protected areas (Smelansky & Tishkov, 2012).

Past and current trends

Each main type of grasslands has had a distinct trend. Here we treat Steppe and Azonal natural grasslands together due to similar trends.

Historically, dry grasslands in Europe and Central Asia were ploughed up and turned into croplands on a massive scale. This was the fate of the wet grasslands as well, which were directly drained, or were drained due to drainage of the neighboring arable fields in the landscape (Stoate et al., 2009). The process had accelerated in the Central Europe in 17th century and came to an end in the mid-20th century in Siberia and Kazakhstan (Hejcman et al., 2013; Moon, 2013; *Russian Steppe Conservation Strategy*, 2006). In England and Wales 97% of semi-natural grassland disappeared by the mid-20th century (Bullock, 2011). Thus, extensive decline in area, increasing fragmentation, and loss of diversity were dominant trends in grasslands for centuries. As a result, only 3-5% of natural steppe grasslands (and azonal grasslands to a significantly lesser extent) remained relatively intact in Europe (Henwood, 2010) and ca. 20% in Russia (Smelansky & Tishkov, 2012). In the only country where grassland are in relatively good status, Kazakhstan, at least 70-80% of the original extent of grassland remains (from 10% to 90% for different steppe and semi-desert types) (Henwood, 2010; Rachkovskaya & Bragina, 2012). An example of a more detailed assessment can be found in Hungary, where approximately 251 thousand ha (6.8%) of the original total of 3.7 million ha of forest-steppe vegetation survived, of which only 5.5% of the stands may be considered natural, 38% semi-natural, 46% moderately degraded, and 10% strongly degraded (Molnár et al., 2012).

The second most important trend in the last millennium was loss or significant decline of two keystone herbivore guilds naturally grazing over grasslands in Europe and Central Asia: wild nomadic ungulates (Pärtel et al., 2005); and colonial burrowing rodents and lagomorphs (Davidson et al., 2012). Both guilds are the main ecosystem engineers in their grassland ecosystems through grazing, trampling, defecating, and digging activities.

A general trend common for steppes and semi-natural grasslands is a strong dependence on traditional agricultural systems, evolved over centuries of land use by local people (Schneider-Binder, 2007). Many grassland variants in Europe and Central Asia developed under or were supported by traditional low-intensity agricultural land use including livestock grazing, hay making, manuring, tillage and burning regimes (Smelansky, 2003). Many grassland species, for example some birds and insects, are dependent on specific agricultural practices in both Europe (Benton et al., 2002; Cardador et al., 2014; Donald et al., 2001; Stoate et al., 2009) and Central Asia (Kamp et al., 2011; Wright et al., 2012). For example, critically endangered sociable lapwing (*Vanellus gregarius*), endemic black lark (*Melanocorypha yeltoniensis*), and some other typical steppe birds strongly prefer heavily-grazed habitats for nesting, but moderately-grazed habitat is optimal for nesting success (Fijen et al., 2015; Sheldon et al., 2013; Watson et al., 2006). Historically, grazing patterns in the steppes of Central Asia

were created and maintained by the traditional mobile pastoralists acting for centuries (Krader, 1955; Leeuwen et al., 1994).

In contrast to traditional farming systems, the more recent intensification of farming has resulted in a dramatic decline of grassland biodiversity. Data from Western Europe show a strong decline of grasslands birds and a 45% decline in the butterfly population in recent decades (Donald et al., 2006; Van Swaay et al., 2013).

In general, habitat and species trends for grasslands in Europe and Central Asia are negative (**Table 3.5**). Habitat degradation is still increasing and habitat area decreasing principally as a result of massive land-use changes and pollution, but significant subregional variation is observed. The conservation status of many endangered species remains unchanged or even becomes worse due to land-use change, overexploitation and pollution. Only species richness is relatively stable, except for semi-natural grasslands, for which it has a negative trend. Climate change accelerates these trends.

Attribution of Biodiversity Trends to Direct Drivers

The most important direct drivers that strongly affect temperate grassland area are ploughing, afforestation, mining and excavation, settlements and industrial area encroachment, land abandonment and climate change (*Cerqueira et al.*, 2015; *Kamp et al.*, 2016; *Korotchenko & Peregrym*, 2012; *Prishchepov et al.*, 2013; *Rachkovskaya & Bragina*, 2012; *Russian Steppe Conservation Strategy*, 2006; *Smaliychuk et al.*, 2016; *Smelansky & Simonov*, 2008; *Smelansky & Tishkov*, 2012) (**Table 3.5**).

Biodiversity and functioning of ecosystems are shaped by differences in subbiome (grassland) type, and latitudinal and evolutionary gradients, site factors (slope, aspect, nutrient status, levels of alkalinity/acidity and moisture); livestock breeding (grazing and mowing), fire, fertilization (manuring, nitrogen deposition), species invasion, and successional dynamics (specifically as a result of abandonment) (*Russian Steppe Conservation Strategy*, 2006; *Faber-Langendoen & Josse*, 2010; *Kamp et al.*, 2016; *Korotchenko & Peregrym*, 2012; *(Merunková et al.*, 2014; *Smelansky & Tishkov*, 2012; ;).

Except for latitudinal and subbiome differences, the abovementioned drivers are caused or influenced by society. Grazing is a major direct factor influencing biodiversity and ecosystem functioning (*Augustine & Mcnaughton*, 1998; *Díaz et al.*, 2007). Fire is another major factor, both through wildfires and prescribed burning. Wildfires (including uncontrolled burning) are practiced in extensive areas in Ukraine, Russia, some Central European countries (Romania, Hungary, Bulgaria) and in Central Asia (*Valkó et al.*, 2016; *Steppe fires and fire management in steppe protected areas*, 2015) as well as in the Mediterranean (*Keeley et al.*, 2012; *Valkó et al.*, 2016). Fertilization leading to eutrophication is especially important for semi-natural grasslands in Western and Central Europe (*Duprè et al.*, 2010). Many drivers lead to fragmentation of grasslands producing a loss of grassland-specific species and degradation of ecosystems.

3.3.2.7 Deserts

Overview of the sub-system

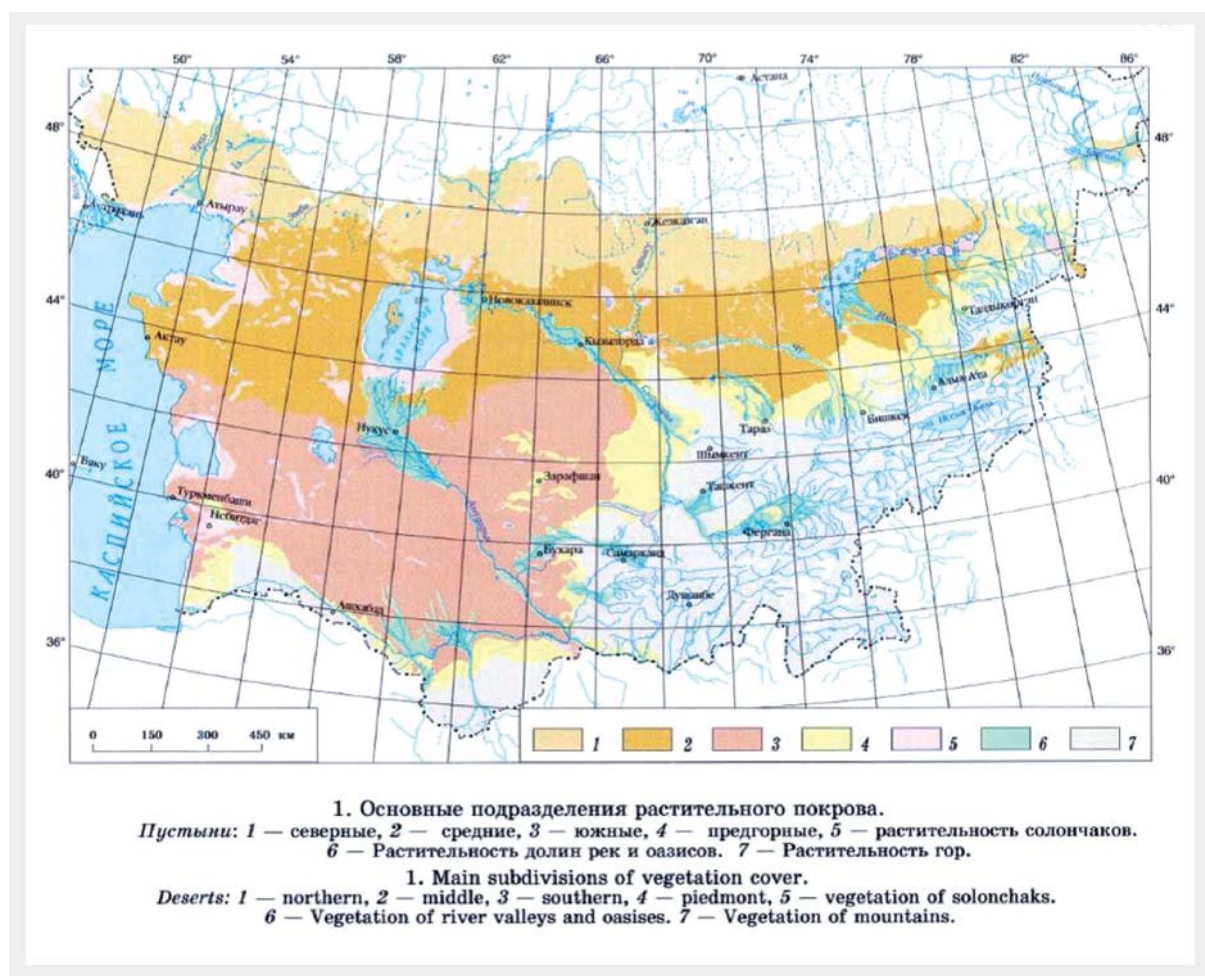
Deserts comprise low and high altitude plains with precipitation of no more than 100 mm/year (FAO, 1989) or no more than 250 mm/year (as per Koeppen-Geiger Classification, *Kottek et al.*, 2006), with rare or absent vegetation on desert soils (*Kharin*, 2002). While the largest extent of deserts is found across Central Asia, the most arid desert in the region is located in Israel (Western Europe in this assessment). The Central Asian deserts extend from the Kopetdag and Paropamiz mountains in the south, to a latitude of 48° north and from the Caspian Sea in the west to the foothills of Jungar Alatau, Tien Shan and Pamir-Altai mountains in the east. This spans about 1400 km from north to south and

2700 km from west to east (Akzhigitova et al., 2003). The Negev Desert in Israel is expanding from the south-eastern section of the Mediterranean Sea eastwards and south-eastwards and with extension northwards along the Dead Sea Rift Valley (Evenary et al., 1982).

Central Asian deserts include: northern or steppified deserts (or semi-deserts) with wormwood gramineous and salt grass plant associations; middle deserts or the true deserts with perennial saltworts and wormwoods and saxaul (*Haloxylon ammodendron*) on sands; and southern deserts with a different composition of wormwoods and salt grass species. Deserts in foothills and in intermontane areas are specifically different in terms of species composition but occupy comparatively small areas (Akzhigitova et al., 2003, **Figure 3.8**).

While the Central Asian deserts form part of the Irano-Turanian floristic region (Takhtadzhyan, 1978; Shmida, 1985), the Negev Desert also has Irano-Turanian vegetation. It becomes increasingly arid towards the south, with features of Saharo-Arabian vegetation. The region has been continuous with the African continent since the Permian (Trewick, 2017; Ziv et al., 2014). Additional more recent geological processes making it a major biodiversity corridor between Africa and Eurasia include the rifting of the Dead Sea Rift Valley (Anker et al. 2009).

Aralkum is a new desert formed as a result of the drying up of the Aral Sea following extensive water consumption for irrigation. The current flora consists of 34 families of plants with 134 genera and 300 species. Aralkum covers an area of over 38,000km² and is a source of windblown dust. Dust storms carry away about 100 million tons of toxic dust and salts annually, including fertilizers and pesticides that have been washed away from irrigated fields (Breckle et al., 2012).



8920

Figure 3.8: Vegetation of Central Asian Deserts (Akzhygitova et al. 2003)Past and current trends and their attribution to direct drivers

The most evident changes of population abundance, functional diversity, and habitat extent in Central Asian deserts were caused by land transformation, fragmentation and degradation (Zoï, 2011). Desert habitats in Central Asia have been fragmented by agriculture for cotton and food production (Kharin, 2002). The irrigated area of Central Asian deserts more than doubled during the 20th century (from 25,000-35,000 km² to 70,000-80,000 km² and reached 100,000 km² in 2013 (Kurtov, 2013). Land degradation caused a species richness decline due to high salinity of abandoned fields. Overall, 40 to 60% of irrigated soils in Central Asia are salt-affected or waterlogged (Gupta et. al., 2009; Zoï, 2011). In the Negev wind and water erosion plays an additional significant role (Verheye, 2009). Removal of sand by winds stimulates sand desert expansion by 3-4 m per year on average and up to 9-12m in Turkmenistan (Veisov et al., 2008).

Central Asian deserts traditionally have been used by local people as pastures – up to 1,700,000 km² during the Soviet Union period (until 1991) (Vinogradov, 1977). Poor pasture management and overgrazing deteriorate the natural vegetation (Gupta et. al., 2009; Turdiboeva, 2015). They were partly abandoned at the end of the last century, but most of the area still suffers from overgrazing, which causes land degradation and species richness decline (Kharin, 2002; Shukurov, 2016). Different natural conditions in the Negev Desert supported different land-use patterns: crop husbandry at the north and grazing in the south, which were based on water-harvesting practices. The history of ecosystem transformation in the Negev is as long as in the Mediterranean (Verheye, 2009). Until recently, the process of desertification did not affect the Negev profoundly. This was mainly due to large-scale afforestation programs, restrictions imposed on grazing, and large water subsidies from the less arid parts of Israel to its more arid areas (Portnov & Safriel, 2004). Presently, overgrazing and aridification contribute to biodiversity decline (Verheye, 2009; IPCC, 2014).

Aridification due to climate change is leading to the increase in desert area and consequent a decline in biodiversity in the centre of deserts (Berseneva, 2006; IPCC, 2014). It also leads to the spread of deserts to the north and high into the mountains in response to warming. This results in loss of biodiversity in former semi-deserts and dry steppes (Glazovsky & Orlovsky, 1996; IPCC, 2014).

Fragmentation of habitats by linear infrastructure interrupts migration routes, for example for globally threatened ungulates leading to decline of their populations: saiga antelope (*Saiga tatarica*), khulan (*Equus hemionus*), Goitered gazelle (*Gazella subgutturosa*) (Olson, 2013; Rosen Michel & Röttger, 2014).

Pollution by fertilizers, pesticides, defoliants used in agriculture (Zoï, 2011), and from mining extraction has a large impact, locally up to the total loss of the vegetation cover (Luryeva, 2014). A particular feature of Central Asian deserts is the impact of the Aralkum that is causing overall species richness decline due to the windborne transfer of hazardous substances from remaining sediments of the former Aral Sea bottom to the surrounding areas (Alikhonov, 2011; Zoï, 2011; Breckle et al., 2012).

In spite of large number of invasive species (57 in Turkmenistan alone) and their competition with native ones, they mainly occur in agricultural and urban territories, so their impact is generally not considered a significant driver of the decline of the number or abundance of populations of native species (Kamakhina, 2008).

3.3.2.8 Peatlands

Overview of the sub-system

Peatlands are areas where water-saturated soil causes the accumulation of incompletely decomposed plant material (“peat”). A peatland which is actively accumulating peat is called mire. Several English terms (e.g., marsh, swamp, fen, bog) are used for naming different mire types (Joosten et al., 2017). Henceforth, this assessment report will use the term peatland. Most national definitions require “peatland” to have a minimum peat depth of 30cm with peat of >30% by dry mass (Joosten & Clarke 2002, Parish et al., 2008, Rydin & Jeglum, 2013). Peatlands have organic soils (histosols), which include soils with shallower organic layers and less organic matter (FAO, 2015). Areas with shallow peat (< 30cm) may cover large areas, as in tundra and boreal zones (e.g. Vompersky et al., 1996, 2011), and in the field are difficult to distinguish from real peatlands, but are usually overlooked and not considered as they usually count as tundra or boreal area (Minayeva & Sirin 2012). Most peatlands of Europe and Central Asia were formed after the last Ice Age (~10,000 years ago), and only very few are much older (Joosten et al., 2017).

Peatlands often demonstrate a unique structural and functional integrity which has developed over centuries. Saturated peatland conditions select the plant species that may grow and form peat. The accumulated peat (which may consist to more than 90% of water) regulates the moisture balance and further determines the habitat for plant growth. Changes in water regime or vegetation may lead to peat and peatland degradation, causing enormous emissions of greenhouse gases (Parish et al., 2008, Hiraishi et al., 2014). Under favourable conditions, however, peatlands may recover (Bonn et al., 2016, Minayeva et al., 2017a).

Past and current trends

Peatlands are found in every country in Europe and Central Asia. In Western Europe peatlands cover 276,323 km², of which 48 % are degraded by drainage for agriculture, forestry and peat extraction, or destroyed by infrastructure development, construction, or flooding by dams (**Figure 3.9**). In Central Europe peatlands cover 47,829 km², of which 74% are drained and degraded. In both subregions some 10% of the former peatland area does no longer have enough peat to be considered as peatlands. In Eastern Europe (including only the European part of the Russian Federation) peatlands cover 267,130 km² of which 38% are drained and degraded (Joosten et al., 2017 and **Figure 3.9**). In the entire Russian Federation peatlands occupy 1,390,000 km² or 8.1% of the country and together with shallow peat lands (<30 cm) as much as 3,690,000 km² or 21.6%. Most peatlands (85%) and shallow-peat lands (84%) are found in the Asian part of the Russian Federation. Almost 20% of the peatlands are underlain by permafrost, of which 5.3% are polygon mires and 14.5% palsa mires (Vompersky et al., 1996; 2005; 2011). Trees are present on 38% of the peatland area, while about 62% is open. Also, 53% of the shallow-peatlands are open (Vompersky et al., 2011). Most peatlands in Russia are still in a natural state. Degraded peatlands are concentrated in the western and central part of European Russia (Minayeva et al., 2005; 2009). In Central Asian countries, peatlands cover only a few thousand square kilometres and are mainly situated in the highlands of Pamir, Tyanshan and Altay (Aljes et al., 2016; Kats, 1971). Highland peatlands play a crucial role for maintaining ecosystem productivity, conserving biodiversity, preserving permafrost, and regulating water supply (Müller et al., 2016). However, they are often overlooked, not considered as peatlands, treated as dry meadows, and therefore rapidly disappearing.

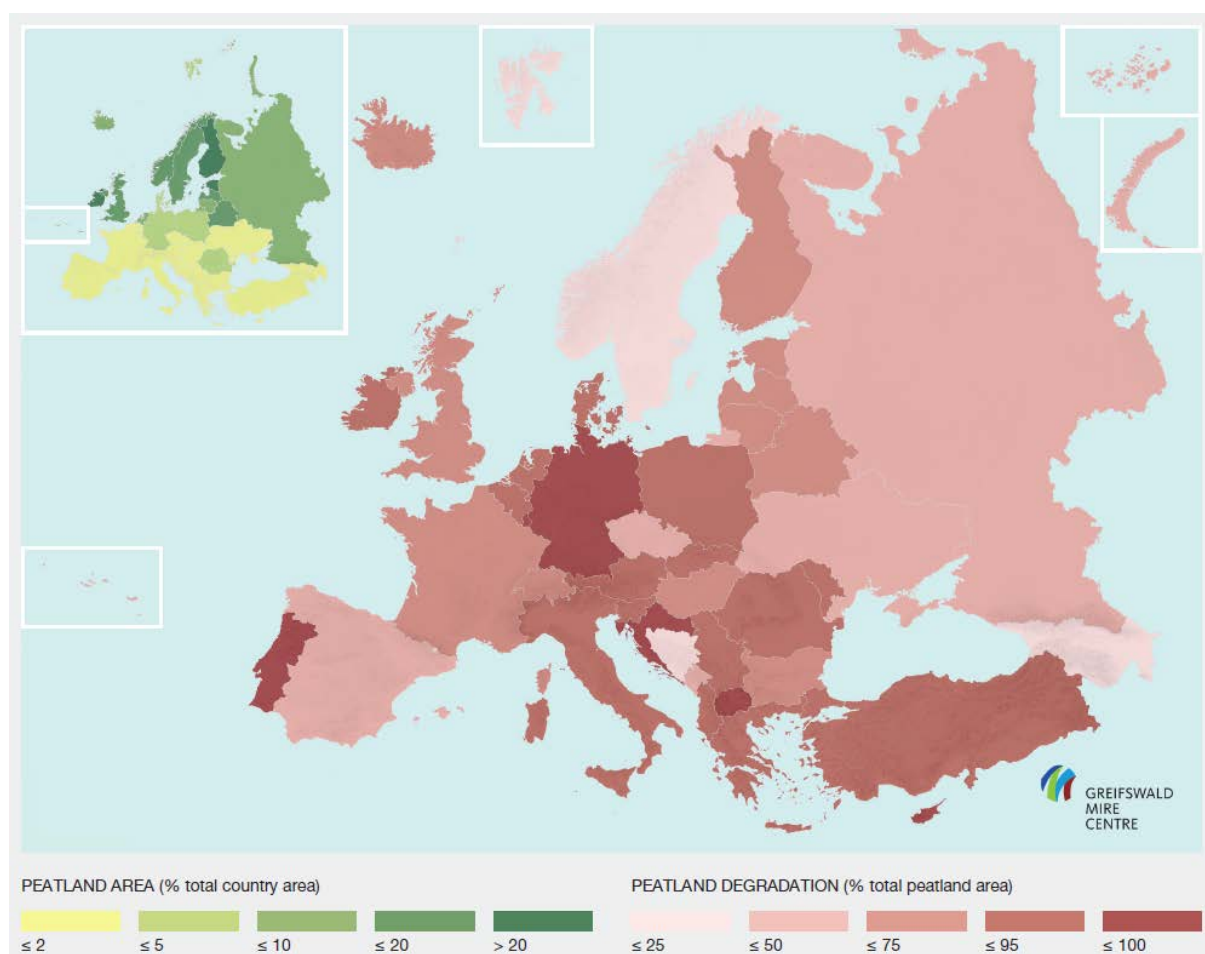


Figure 3.9: Proportion of current peatland area (% total country area) and proportion of degraded peatland area (% total peatland area) in Western and Central Europe and the Western part of Eastern Europe (based on data from Joosten et al. 2017 and Global Peatland Database/Greifswald Mire Centre, map prepared by C. Tegetmeyer). Note: in many countries, the original peatland area was substantially larger than the current peatland area.

Peatlands in Europe and Central Asia in the past demonstrably suffered from long-term climate warming (Klimanov & Sirin, 1997), but their diversity and the variety of geographical conditions prohibit drawing unequivocal general conclusions on their reaction to climate change, especially on the scale of decades (Parish et al., 2008).

Attribution of biodiversity trends to direct drivers

Peatlands as ecosystems are rather well adapted to climate change (Minayeva & Sirin, 2012). However, especially in the 19th and 20th centuries, anthropogenic transformation (drainage for agriculture, forestry, peat extraction, infrastructure) has substantially reduced this resilience. Northern permafrost peatlands, which are most sensitive to climate change, are progressively affected by industrial development and intensification of traditional land use (Minayeva & Sirin, 2009; 2010). In the temperate and boreal zones peatlands have been widely drained and used for forestry, agriculture and peat extraction. Many of the earlier drained areas are currently abandoned and subject to – sometimes catastrophic – fires (Minayeva et al., 2013; Sirin et al., 2011).

Boreal peatlands currently show a gradual reverse from drainage-based exploitation towards protection and restoration. In the temperate zone a growing appreciation for ecosystem services has

initiated peatland rewetting projects to reverse the impacts of drainage. At the same time, however, the demand for biomass has caused massive expansion of biomass cultivation on peatlands with deeper drainage and more fertilization, which dramatically changes peat soil properties. In semi-arid and desert regions peatlands are being destroyed by overgrazing and drainage, while highland peatlands are often affected by mining. Overgrazing on peatlands leads to peat degradation, massive CO₂ emissions, and a loss of storage and retention capacity for carbon and water (Sirin et al., 2016). All these hazards are aggravated by climate change, especially by decreasing precipitation, rising temperatures, and increased probability of catastrophic events such as droughts, rain storms or fires.

The resilience of natural peatlands to climate change is based on their self-regulation, but this capacity is not unlimited (Minayeva & Sirin, 2012). Substantial changes in peatland hydrology (by drainage), soil hydraulic properties (by long-term drainage), and peatland relief (by oxidation, subsidence and peat extraction) make spontaneous and supported recovery more and more complicated (Parish et al., 2008). In damaged peatlands, climate change is expected to increase the probability of catastrophic events, such as peat fires (Minayeva et al., 2013; Sirin et al., 2011), erosion, and inundation, and will impair the further provision of important ecosystem services, such as carbon storage and water regulation (Parish et al., 2008, Bonn et al., 2016). As peatland degradation enhances climate change (because of the enormous emissions involved (Hiraishi et al., 2014), the impact on biodiversity reaches far beyond the boundaries of the peatland itself.

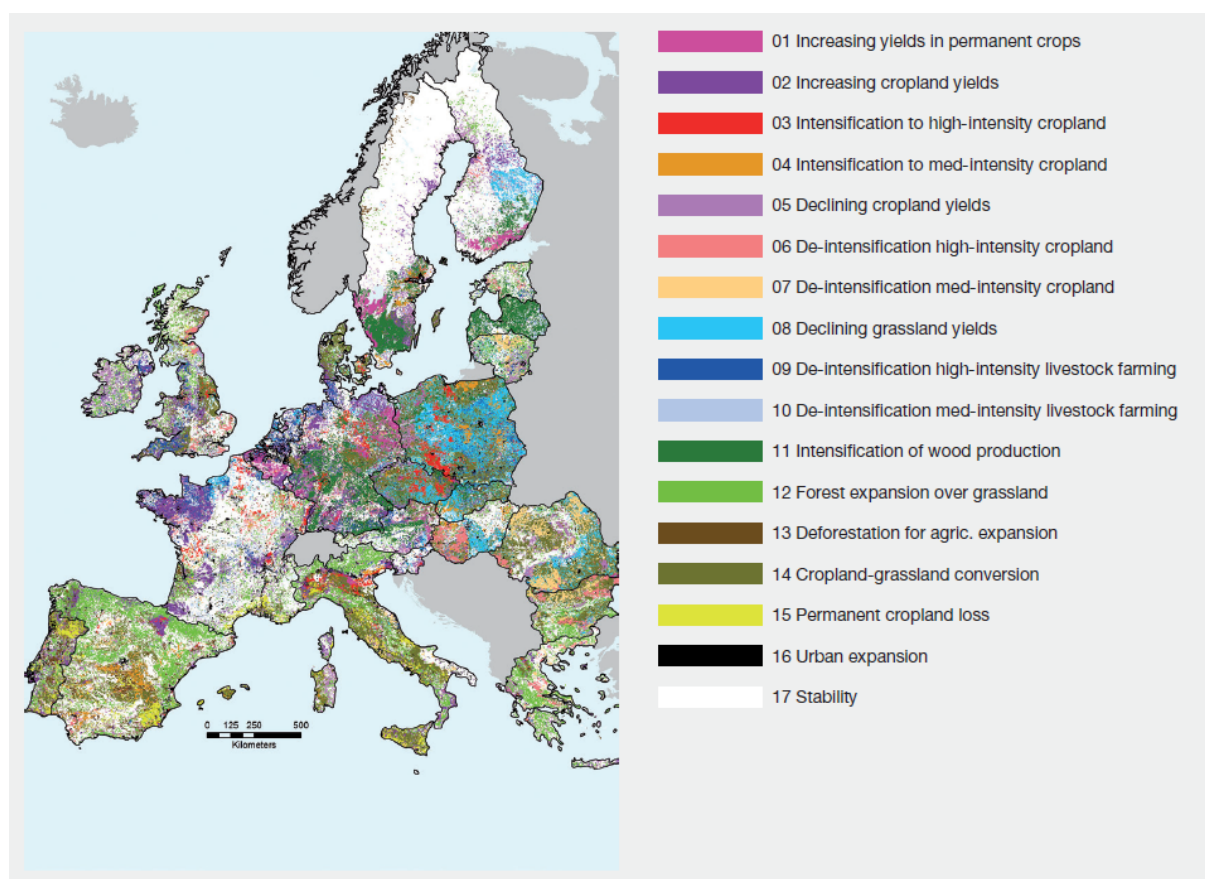
3.3.2.9 Agricultural areas

Overview of the sub-system

Agroecosystems include croplands, orchards, horticultural systems and managed grasslands (note that alpine grasslands and natural or semi-natural grasslands are addressed in other sections). Agricultural areas cover around half of the land area and thus represent the largest terrestrial unit of analysis over Europe and Central Asia (EEA, 2015; FAO, 2013; Levers et al., 2015).

Past and current changes in the extent and diversity in agroecosystems

The legacy of traditional, low-intensity and diverse agricultural systems in Europe and Central Asia is a rich diversity of habitats and landscapes, generally supporting high levels of biodiversity (STOA, 2013 and references therein). However, agroecosystems and their diversity have changed dramatically since the early 1950s, and there has been an increase of highly modified and simplified agroecosystems and agricultural landscapes, in particular in Europe (Polakova et al., 2011). From 1990 to 2006, land-use conversion, de-intensification and intensification took place on 26%, 18% and 15% of land areas, respectively, which corresponds with huge changes in the extent of different agroecosystem types (**Figure 3.10**).



9064

9065 **Figure 3.10: Spatial distribution of the main changes in the extent of agroecosystem types (classes**
 9066 **01 to 10, 13 and 14) between 1990 and 2006 in the EU-27. After Levers et al. (2015).**

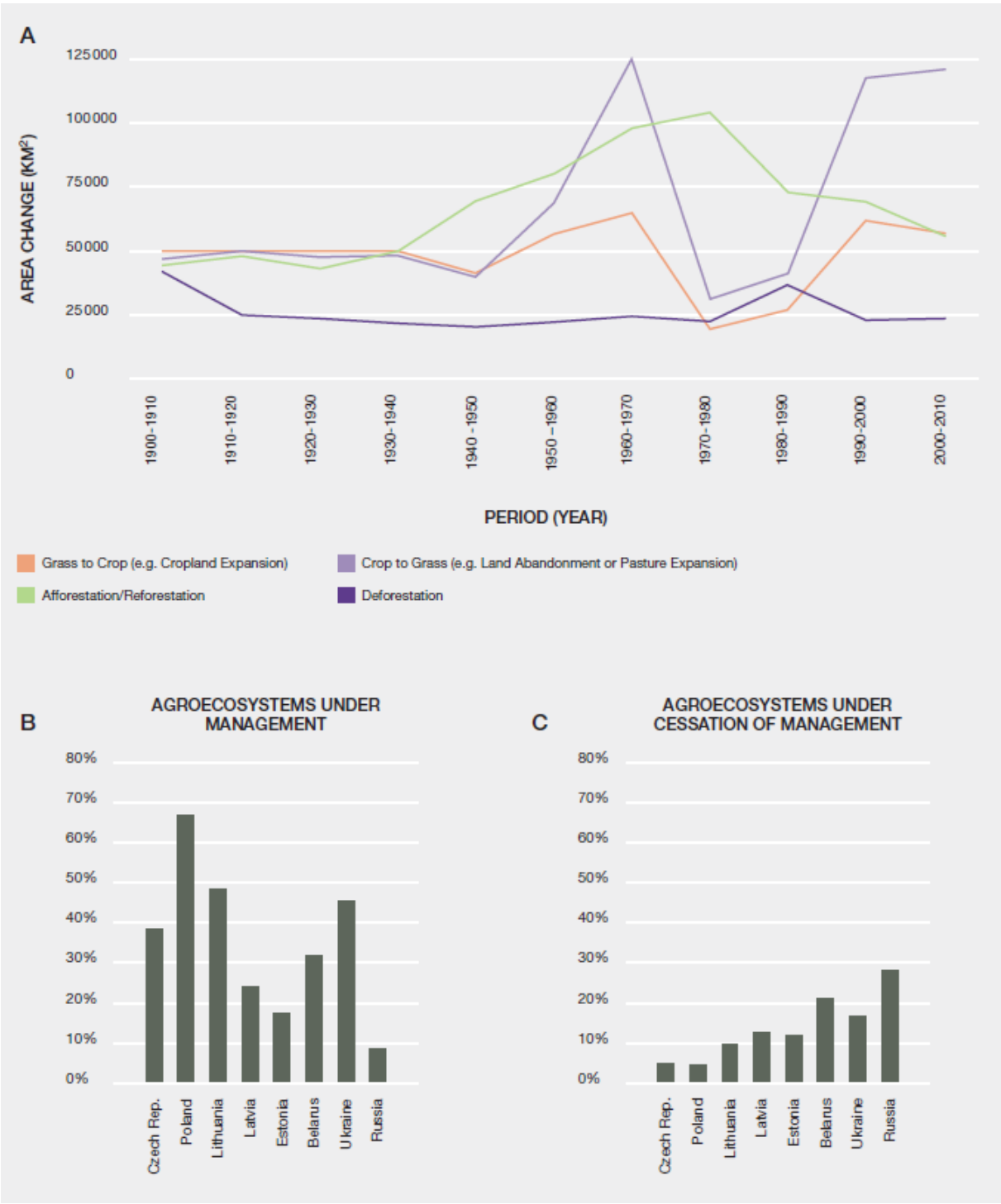


Figure 3.11: A: Major gross area changes between the different types of agroecosystems observed for EU-27 and Switzerland per decade since 1910. After Fuchs et al. (2015). B: Extent of agroecosystems under management; and C: experiencing cessation of management assessed in 2005 for areas in eight countries of Baltic, central Europe and eastern Europe. After Alcantara, Kuemmerle, Prishchepov, & Radeloff (2012).

De-intensified agroecosystems dominated in Eastern Europe and Central Europe (3.5; see also Kuemmerle et al., 2016) and in Central Asia (Kraemer et al., 2015), along with abandoned farmland after the collapse of the Soviet Union (e.g. 26million ha in Russia, Belarus, Ukraine and Kazakhstan (Lambin and Meyfroidt, 2011)). A vast area experienced spontaneous recovery of forest and steppe

ecosystems (Kamp et al., 2015). Remote, economically unproductive agroecosystems are increasingly abandoned, reforested, or included in rewilding schemes (MacDonald et al., 2000; Navarro and Pereira, 2012). For the EU-27 plus Switzerland, gross changes in the extent of the different types of agroecosystems resulted in changes to 56% of the area (ca. 0.5% /yr) between 1900 and 2010. This covers twice the area of net changes, with main changes being cropland or grassland dynamics and afforestation (**Figure 3.11** left). Within agricultural landscapes, decreased crop diversity, decreased coverage of natural and semi-natural areas (hedgerows, isolated trees, ponds, permanent grasslands) and lower connectivity between the remaining natural and semi-natural habitats are generally observed in response to intensification of agricultural systems (Robinson and Sutherland, 2002; Stoate et al., 2001, 2009). For instance, hedgerow length and connectivity have strongly decreased in Western Europe (Deckers et al., 2005; Robinson and Sutherland, 2002).

Ample information is available on the status and temporal trends of biodiversity for some broad taxonomic or functional groups in Europe and Central Asia, or at least for Western Europe and Central Europe. A vast number of scientific papers report temporal trends of biodiversity components in agricultural areas in locations or (sub)regions of Europe and Central Asia. Well established information exists for farmland birds (e.g. work of the European Bird Census Council covering at least 28 countries), arable flora (meta-analyses covering croplands from many countries), grassland butterflies (covering 19 countries), and the diversity of avian and mammalian breeds (syntheses performed by FAO over Europe and Central Asia). For the diversity of cultivated crop plants, comprehensive information exists for the number of varieties conserved ex situ, but not for the trends in the (genetic and functional) diversity of major cultivated varieties actually cultivated, i.e. grown in situ. In contrast to the Western Europe and Central Europe subregions, agricultural lands in Eastern Europe and Central Asia are often not recognized as having high conservation value, and research on trends of biodiversity in agricultural areas is rare. We summarize the major trends for different components of biodiversity in agricultural areas of Europe and Central Asia in **Table 3.1**.

Table 3.1: Summary of the major trends reported for several components of biodiversity in agricultural areas in Europe and Central Asia, based on the analysis of over 150 temporal trends reported in the literature. For trends in pollinators, see IPBES (2016a). ↑/↓ denote strong and consistent increase/decrease in the indicator; ↗/↘ denote moderate and consistent increase/decrease in the indicator; ↔ stable indicator; ⬆ inconsistent trend in the indicator. The numbers reflect the impact of the driver on the trend: 0 no or marginal impact; 1 moderate impact; 2 high impact. P=Past, C=Current.

Biodiversity Indicators		General trends		Importance of Direct Drivers									
				Climate		Land use*		Pollution*		Exploitation		Invasives	
		Past	Current	P	C	P	C	P	C	P	C	P	C
Farmland birds	Species richness	↘ ↘↘↘↘	↘ ↘↘↔↘	1	1	2	2	1	1	0	0	0	0
	Species abundance	↓ ↓↘↘↘	↘ ↘↘↗↔	1	1	2	2	1	1	0	0	0	0
	Functional diversity	↘	↘	1	1	2	2	1	1	0	0	0	0
Avian breeds	Breed richness	↘ ↓↘↘↘	↘ ↘↘↘↘	0	0	2	2	0	0				
	Local breed abundance	↘ ↓↘↘↘	↘ ↘↘↘↘	0	0	2	2	0	0				
	Genetic diversity	↘ ↓↘↘↘	↘ ↘↘↘↘	0	0	2	2	0	0				

Mammal breeds	Breed richness	↘ ↓↘↘↘	↘ ↘↘↘↘	0	0	2	2	0	0				
	Local breed abundance	↘ ↓↘↘↘	↘ ↘↘↘↘	0	0	2	2	0	0				
	Genetic diversity	↘ ↓↘↘↘	↘ ↘↘↘↘	0	0	2	2	0	0				
Butterflies	Species richness	↘	↘			2	2	2	2	0	0		
	Species abundance	↘	↘			2	2	2	2	0	0		
	Functional diversity	↘	↘	1	1	2	2	2	2	0	0		
Arable plants / weeds	Species richness	↘	↘	0	0	2	2	2	2	0	0	1	1
	Species abundance	↘	↘	0	0	2	2	2	2	0	0	1	1
	Functional diversity	Shift	Shift	0	0	2	2	2	2	0	0	1	1
Cultivated plants	Ex situ variety richness	↑ ↑↑↑↑	↑ ↑↑↑↑	0	0	2	2	2	2				
	Ex situ genetic diversity	↕ ↕↕↕↕	↕ ↕↕↕↕	0	0	2	2	2	2				
	Ex situ functional diversity	↘	↘	0	0	2	2	2	2				
	In situ genetic diversity	↘	↘	0	0	2	2	2	2				

*Agriculture intensification encompasses both land-use change and pollution (fertilization, pesticide application)

Farmland birds - From 1980 to 2013, the abundance of common farmland bird species has continuously been decreasing (by 57% in total) in Europe, although the slope of decrease is lower since the 1990s (**Figure 3.12**). Since 1990, the decline is more pronounced for northern Europe, intermediate for western Europe and new European Union member States, and less important for southern Europe (**Figure 3.12**). In addition, the functional diversity of farmland bird communities is changing. The abundance of 17 granivorous species and 14 insectivorous species decreased strongly (56% and 46%, respectively), while the abundance of other species (one herbivore, two omnivores, one carnivore and one aerial insectivore) remained constant over 28 European countries (Inger et al., 2015)²⁴. Overall, farmland bird communities become more homogenized (Doxa, Paracchini, Pointereau, Devictor, & Jiguet, 2012).

²⁴Inger et al. kindly reanalysed their published data and computed trends for farmland birds for the present assessment

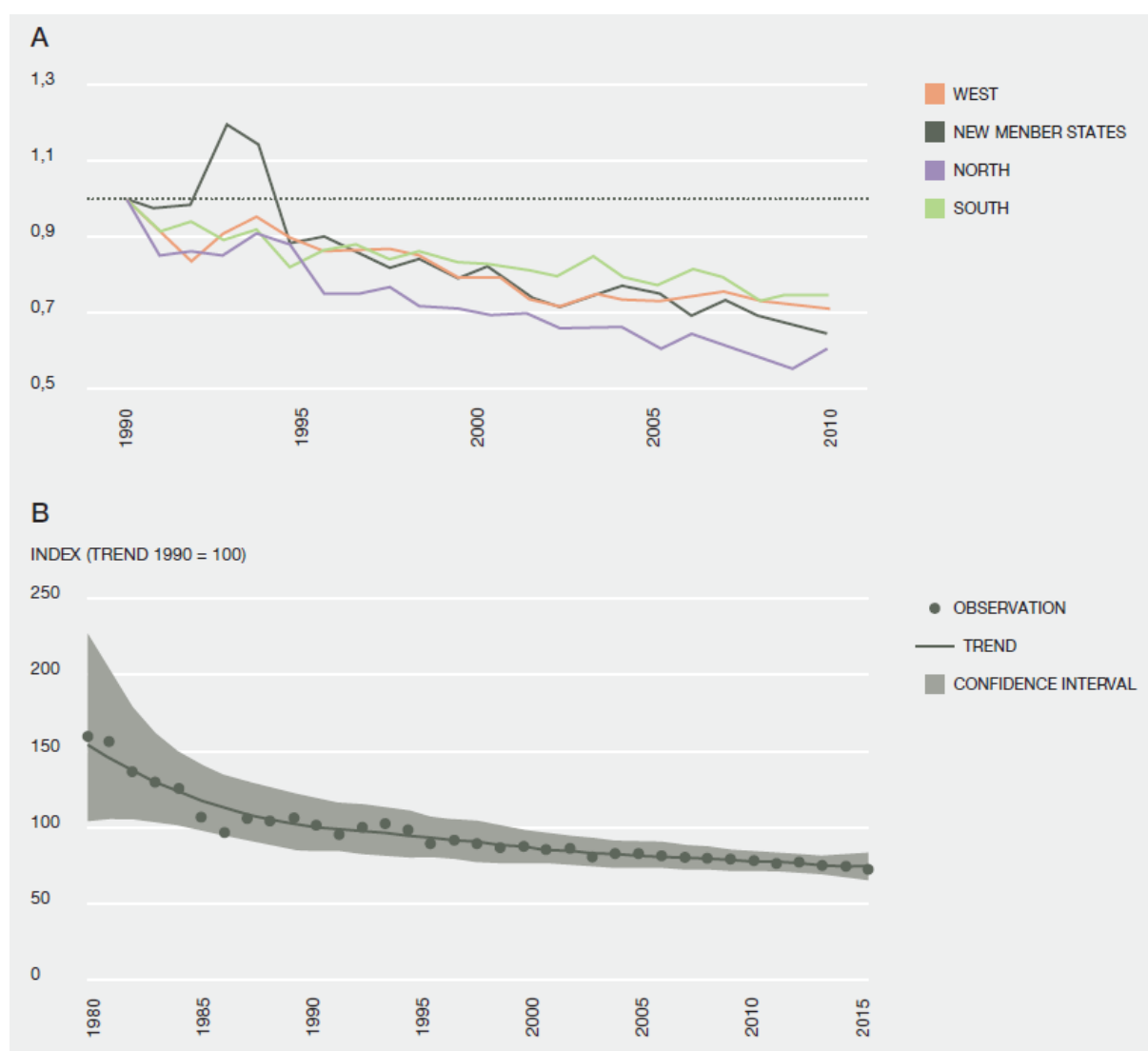


Figure 3.12: A: Temporal variations in the abundance of common farmland birds between four European subregions between 1990 and 2011. After Pe'er et al. (2014). B: Temporal variation in the abundance of common farmland birds for 28 European countries and for 39 species from 1980 to 2015. Source: <http://www.clo.nl/en/indicators/en1479-farmland-birds>.

Over the past 25 years in the Eastern Europe and Central Asia subregions the dynamics of farmland bird populations have been mainly driven by the crucial land-use changes related to transition from the Soviet-era planned economy to a market economy. The 1991-2001 period was characterized by massive land abandonment, decreasing crop yields and livestock numbers, and decline of fertilizer and pesticide use, which led to increases of the abundance and species richness of farmland birds in the steppe and forest-steppe geographical zones (Bolnykh & Vengerov 2011; Kamp et al., 2011, 2015; Korovin, 2015), whereas in the forest zone this promoted an opposite trend (i.e. decreasing abundances and diversity) due to spontaneous reforestation, decreased open habitat areas and reduced habitat diversity (Borisov et al., 2014). At least in part of the Central Asia and Eastern Europe subregions, farmland bird populations have decreased again since the early 2000s (Kamp et al., 2015).

The abundance of grassland butterflies has declined by 30% in 22 European countries from 1990 to 2015 (**Figure 3.13**). Butterfly communities also became more homogenized (Eskildsen et al., 2015). However, this negative trend has been locally reversed in some cases (**Box 3.1**).

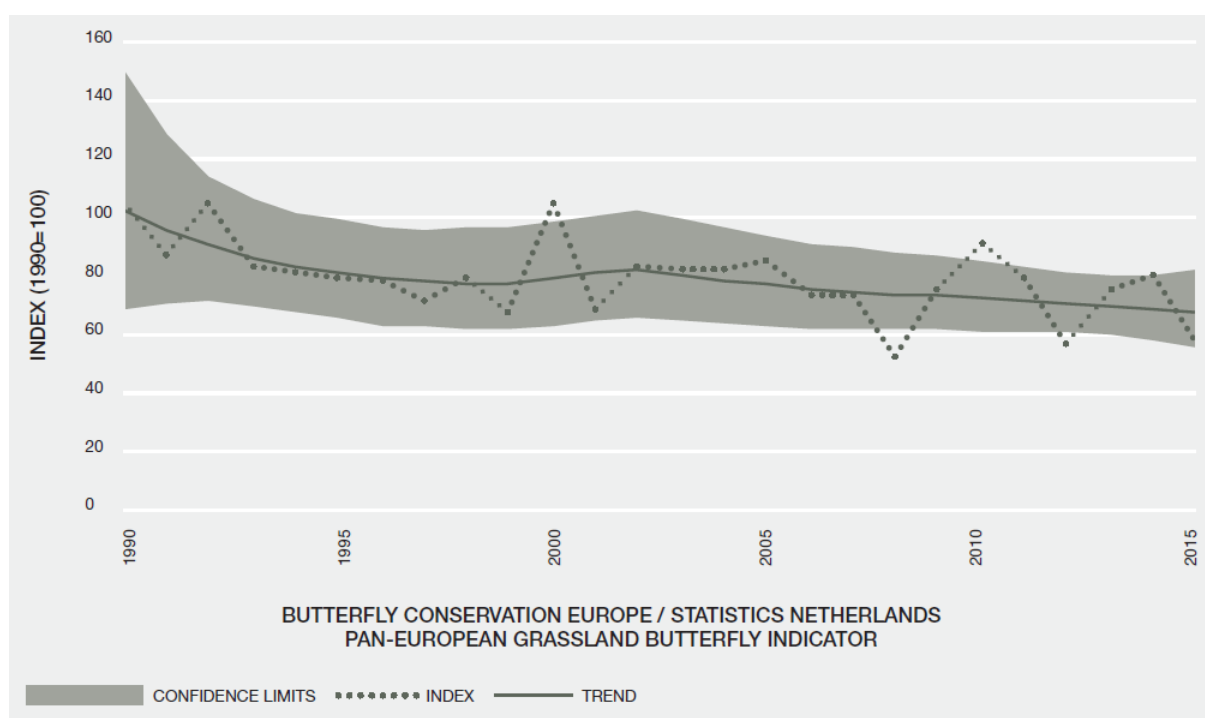


Figure 3.13: Temporal variation in the abundance of 17 grassland butterfly species averaged across 22 European countries during the 1990-2015 period. After van Swaay and et al (2017).

Box 3.1 Reversing the decline of biodiversity in agricultural areas: a success story for a butterfly species.

Ecological knowledge was successfully used to guide innovative conservation practices allowing the reversal of the decline of *Maculinea arion*, a charismatic specialist whose larvae parasitize *Myrmica* ant societies (Thomas, Simcox, & Clarke, 2008). *M. arion* larvae were found to be adapted to a single host-ant species inhabiting a narrow niche in grassland. Inconspicuous changes in grazing and vegetation structure caused host ants to be replaced by other ant species unsuitable for the butterfly larvae, explaining the extinction of European *Maculinea* populations. Once this problem was identified, ecosystems were perturbed by appropriate practices, and the predicted subsequent recovery of the butterfly and ants was validated for 78 sites. Such successful identification and reversal of the problem provides a paradigm for other science-based actions to reverse the decline of biodiversity in agricultural areas.

End of Box 3.1

Agriculture-detrimental and beneficial insects – Temporal trends in the abundance or distribution of insects, which can cause major changes for agriculture have been reported. For instance, important changes in the distribution of crop pests, in particular due to climate change in northern areas of Europe and Central Asia, have been reported (Frolov et al., 2014; **Figure 3.14** left). Evidence also accumulates of significant declines for both managed and wild bees (including bumblebees) over the past 60 years in Europe, which has been recently synthesized by a thematic IPBES assessment (IPBES, 2016a). In particular, there have been severe losses of honey bee colonies reported for the 1961-2012 period in many countries of Europe and Central Asia (**Figure 3.14** right). However, in the countries of Central Europe, Eastern Europe, and Central Asia subregions, the hive numbers show marked trends of recovery during the past decade (Kazstat, 2005, 2016; Rosstat, 2015).

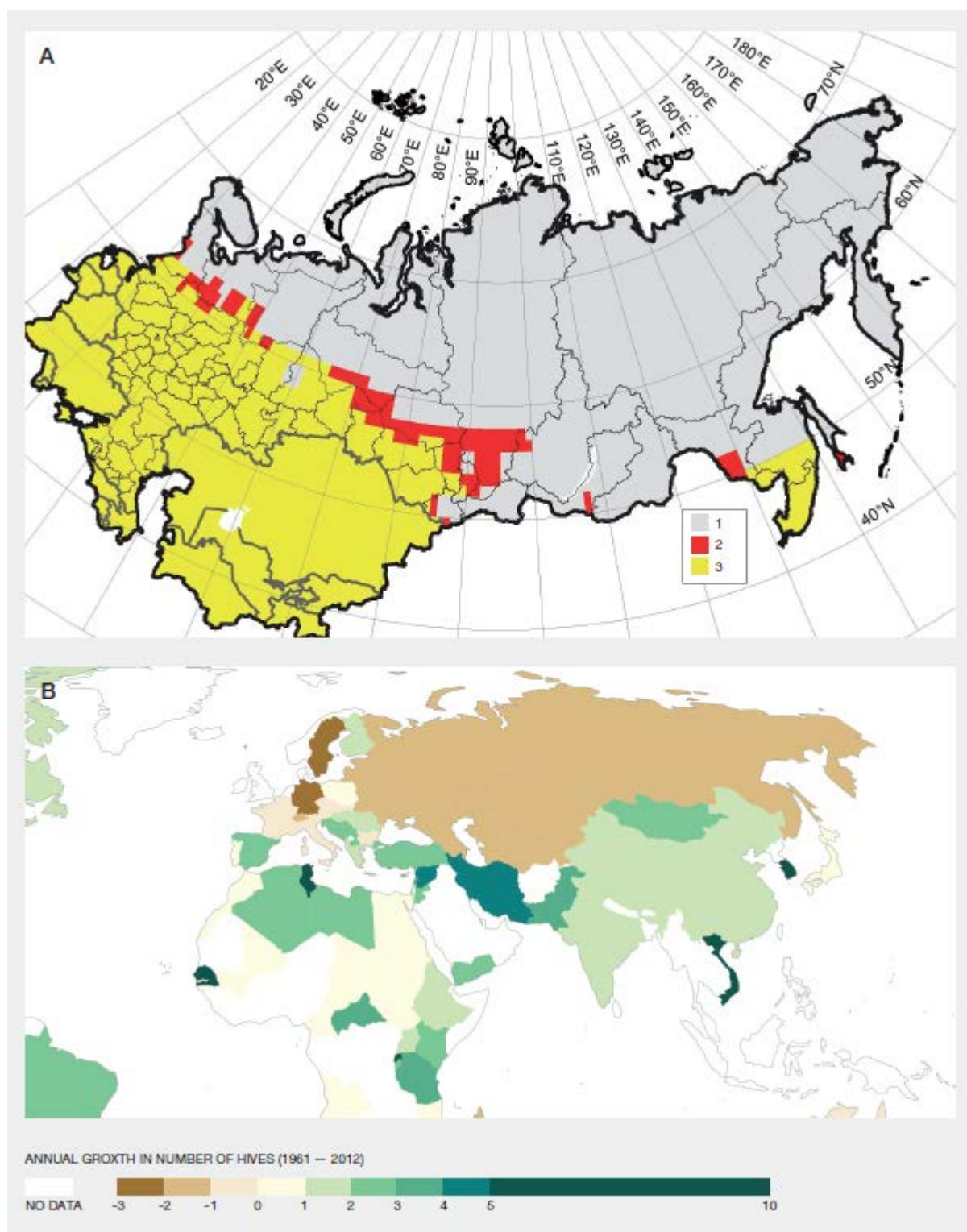


Figure 3.14: A: Change in the climatic range of the Colorado beetle from 1991 to 2010 compared with 1951 to 1970 (Popova, Semenov, 2013). 1: unsuitable areas for the beetle; 2: range increment; 3: suitable in both periods. B: Annual growth rate (%/yr) in the number of honey bee colonies for countries reporting those data to FAO between 1961 and 2012 (FAOSTAT, 2013).

Animal genetic resources for food and agriculture – geographical Europe and the Caucasus have by far the highest proportion of animal breeds at risk in the world (31 and 35 per cent of mammalian and avian breeds, respectively) and the highest absolute number of at-risk breeds (446 mammalian and 75 avian breeds corresponding to 79% and 91% of total breed extinction at global scale, respectively)

(Figure 3.15). In several countries, populations of native breeds, although generally well adapted to local circumstances and resources and forming an important part of our cultural heritage and regional identity in Europe and Central Asia, remain at critically low numbers, being replaced by a few and widespread highly productive breeds. Native breeds make up only a small part of the total population, and nearly 40% of native breeds are at risk in Europe and Central Asia, i.e. the highest value for all global regions (FAO, 2015). Overall, the situation of animal genetic resources is stable but negative in Europe and Central Asia.



Figure 3.15: Risk status of mammalian breeds in geographical Europe and the Caucasus up to December 2005. Relative (Figures) and absolute (Tables) numbers are presented. After (FAO 2007).

Arable plants and weeds - The species diversity of arable plants has decreased since 1950 (by around 20%; (Richner, Holderegger, Linder, & Walter, 2015). The abundance of arable plants has also decreased (Meyer, Wesche, Krause, & Leuschner, 2013; Richner et al., 2015). In particular, the abundance of rare arable plant species characteristic of traditional management has decreased since the 1950s. These trends probably hold true all over Europe and Central Asia. The functional diversity of arable plants has changed from the 1950s to 2011, with an increase of arable weeds linked to high nutrient demand and resistance to extreme pH, and herbicides (Richner et al., 2015). 25% of weed taxa are threatened in Tajikistan, including 18 endemic and four subendemic plants (Nowak & Nowak, 2015; Nowak, Nowak, Nobis, & Nobis, 2014)

Plant genetic resources and crop wild relatives for food and agriculture - The number of plant varieties conserved *ex situ* has increased in Europe, as a result of selection and efficient storage approaches. However, much of the diversity of crop wild relatives and underused species relevant for food and agriculture still needs to be secured for present and future use (FAO, 2015). Regarding the genetic

9199 diversity of crop plants actually cultivated *in situ*, a reduction in diversity occurred up to the 1960s due
 9200 to the replacement of landraces by modern cultivars and to the low number of cultivars actually
 9201 cultivated over large areas, while no further reduction or increase of diversity was observed after 1980
 9202 (Bonnin, Bonneuil, Goffaux, Montalent, & Goldringer, 2014); but the trend is likely species-specific.
 9203 However, the actual genetic diversity of crop species found in fields is often not documented.

9204 Among 572 species of European wild relatives of economically important crop species, 11% are
 9205 threatened, and a further 4.5% of the species are near threatened (Bilz, Kell, Maxted, & Lansdown,
 9206 2011b; Kell, Maxted, & Bilz, 2012). More species are threatened at national level.

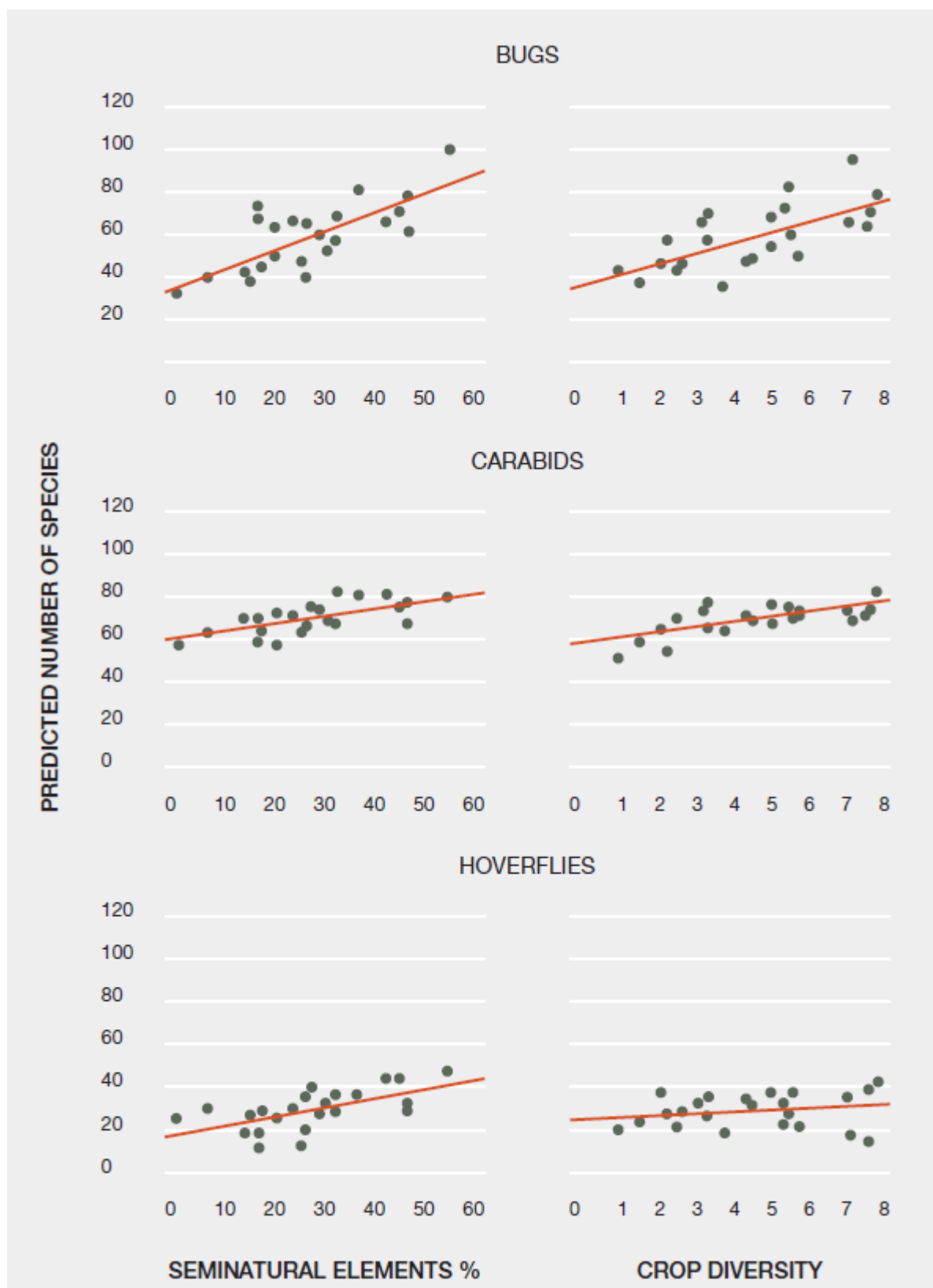
9207 While scientific publications on biodiversity trends in agricultural areas in Central Asia and some parts
 9208 of Europe are not numerous, precious information can be derived from indigenous and local
 9209 knowledge. For instance, Hungarian herders have a deep understanding of biodiversity and its trends
 9210 in managed grasslands, and they also report a biodiversity decline, in particular for bird and plant
 9211 species richness and abundances (Molnár, 2014; Varga & Molnár, 2014).

9212

9213 Attribution of biodiversity trends to direct drivers

9214 **Main drivers influencing biodiversity in agricultural areas:** The moderate utilization of lands in
 9215 historical times was associated with high species richness in the rural landscape of Europe (Kull and
 9216 Zobel, 1991; Pykälä, 2007), leading to the concept of high nature value farmland (Halada, Evans,
 9217 Romão, & Petersen, 2011). The traditional, non-intensive agriculture and the management of marginal
 9218 lands generally have a positive role in maintaining high biodiversity levels.

9219



9220

9221 **Figure 3.16: The species richness of aboveground invertebrate groups (here bugs, carabids and**
 9222 **hoverflies) increases with the percentage of semi-natural elements and crop diversity in twenty-five**
 9223 **16-km² agricultural landscapes from seven European countries. After Billeter et al. (2008).**

As reported by a large majority of the many studies on this subject, lower biodiversity levels are very generally observed with increasing intensification of agricultural systems (Le Roux et al., 2010). These are mostly related (1) at the landscape scale to decreased percentage of natural and semi-natural elements, decreased habitat diversity or crop diversity, and to a lesser extent reduced coverage of extensively managed crops; (2) at the field scale to increased addition of pesticides and fertilizers, and other practices like drainage; and to a lesser extent (3) to decreased connectivity between habitats (Le Roux et al., 2010; STOA, 2013) (**Figure 3.16**).

Overall, the effects of the level of agricultural intensification on the diversity of several taxonomic groups are now well documented, but are complex and depend on both the considered group, aspect of intensification and spatial scale (e.g. Jorgensen et al. 2016 for farmland birds). Intensive farming also has impacts on biodiversity outside agricultural areas and outside Europe and Central Asia (STOA 2013). In parallel, partial or complete abandonment of agricultural management on non-intensively managed systems is a major threat to biodiversity in Europe and Central Asia (Billeter et al., 2008; STOA, 2013), and many studies have reported that biodiversity declines following abandonment for several biological groups (Le Roux et al. (2009) and references therein). In parts of Central Asia, the decline in cooperative farms and intensive agriculture based on relatively few economically important crops has led to a return to a more diverse crop production, offering opportunities to biodiversity.

Main drivers influencing particular taxonomic groups: The steep decline in farmland bird populations during the 1980s and 1990s was associated with increasing agricultural specialisation and intensity in some areas, and large-scale marginalisation and land abandonment in others (Pe'er et al., 2014). As these changes have expanded eastwards, a steeper decline has been reported in Central Europe in recent years (EBCC 2013). Agri-environment schemes implemented after revision of the European Union's agri-environmental programs in 2007 were not more effective for farmland bird diversity than schemes implemented before revision (Batáry et al., 2015). In post-soviet countries in Eastern Europe and Central Asia, the dynamics of farmland bird populations were mainly driven by land-use changes linked to the transition to the market economy (Kamp et al., 2015; Kessler & Smith, 2014).

Intensifying agriculture on the one hand, and abandoned land (mainly in Eastern Europe and Southern parts of Western and Central Europe) on the other, are the two main driving forces affecting the populations of grassland butterflies (van Swaay et al., 2015).

Evidence has accumulated of a significant decline in populations of bees (including bumblebees) over the past 60 years in geographical Europe, resulting mainly from agriculture intensification (IPBES, 2016b). Many of the environmental threats to wild bee diversity in Europe are associated with modern agriculture and, in particular, shifting agricultural practice and increasing intensification of farming (Nieto et al., 2014). In addition, while agriculture has become increasingly pollinator-dependent, the number of honeybees required to provide crop pollination across 41 countries from the region has risen 4.9 times faster than honeybee stocks between 2005 and 2010 (Breeze et al., 2014; Schatz & Dounias, 2016).

Bats, rodents, and herbivorous and carnivorous mammals, are all in decline due to agriculture intensification in geographical Europe since mid-20th century (e.g. Flowerdew, 1997; Pocock and Jennings, 2008). Among different drivers linked to intensive agriculture (Stoate et al., 2009), molluscicides and rodenticides are considered the greatest risk to mammals, both through primary and secondary exposure (Shore et al., 2003), while poisoning by pesticides persists or tends to decrease locally (Barnett et al., 2006). It is noteworthy that several large mammals such as the wolf (*Canis lupus*), brown bear (*Ursus arctos*), lynx (*Lynx lynx*) wild boar (*Sus scrofa*), and moose (*Alces alces*), are probably gaining from land abandonment, expansion of forest cover or subsequent increase in ungulate mammal prey in Europe and Central Asia (Moreira and Russo, 2007; Falcucci et al., 2007; Russo, 2007;

9270 Sieber et al., 2015).

9271 **The role of ecologically-friendly agricultural practices:** During recent decades, agricultural practices
 9272 and systems alternative to intensive ones have been developed (including new practices or previously
 9273 widespread ones), such as leaving field margins unsprayed, stricter pesticide management, reduced
 9274 tillage, and organic farming (ECC, 2009; see Chapter 4 for details and temporal trends). The effects of
 9275 these “ecologically-friendly” agricultural practices on biodiversity are generally positive, but can vary,
 9276 e.g. according to the landscape context and spatial scale of evaluation.

9277 In particular, organic farming has been shown to increase local species richness of wild organisms,
 9278 although with large variation between studies (Tuck et al., 2014). The effect differs between taxonomic
 9279 groups (Dicks et al., 2016; Fuller et al., 2005), with particularly beneficial effects on plants and
 9280 pollinators (Batáry et al., 2011, Tuck et al., 2014). Other differences between studies can be attributed
 9281 to the effect of landscape context (Tuck et al., 2014), the local extent of organic farming (Gabriel et al.,
 9282 2010) and time since conversion to organic farming (Jonason et al., 2011). However, beneficial effects
 9283 of organic farming may be mainly local (Bengtsson et al., 2005), and it is not clear whether effects on
 9284 local biodiversity scale up to effects on biodiversity at regional scales (Gabriel et al., 2006; Schneider
 9285 et al., 2014).

9286

9287 **Box 3.2 Does biodiversity increase in response to agri-environmental schemes?**

9288 A meta-analysis (Batáry et al., 2015) showed that agri-environment schemes benefit species richness and
 9289 abundance, but several reviews reported that current schemes are not sufficient to reverse the decline
 9290 of farmland biodiversity in Europe (Berendse et al., 2004; Kleijn et al., 2006). This is likely due to the fact that
 9291 many agri-environment schemes do not sufficiently target biodiversity conservation or are not applied over a
 9292 sufficient land cover (STOA, 2013; see Chapter 6).

9293

9294 **End of Box 3.2.**

9295

9296 Given the low uptake of organic farming in areas with high agricultural intensification, where the
 9297 effects on biodiversity would be greatest (Rundlöf and Smith, 2006), the actual effect of organic
 9298 farming on general biodiversity trends may be smaller than expected. Organic farming may contribute
 9299 to the maintenance of agriculture in marginal areas of high value for biodiversity (Gabriel et al., 2009),
 9300 but the extent of this effect remains unknown.

9301 The question of how farmland conservation initiatives actually contribute to the policy objectives of
 9302 halting the decline of agrobiodiversity largely remains to be addressed in a quantitative manner (see
 9303 Kleijn et al. (2011) and references therein) and using adequate indicators.

9304

9305 *3.3.2.10 Urban areas*

9306 Overview of the sub-system

9307 Urban green infrastructures comprise systems of indigenous habitats, formal (e.g. parks, cemeteries)
 9308 and informal (e.g. ruderal, transportation areas) green space, artificial habitats (e.g. green roofs and
 9309 walls, ponds), semi-natural and rural habitats. Taxa that occupy these habitats vary in their sensitivity
 9310 to urbanization, with some assemblages comprising generalist species and others retaining specialist
 9311 species and contributing more to biodiversity (Niemelä & Kotze, 2009). During the expansion phases
 9312 of cities, both through outward expansion into the peri-urban region and densification, changes occur
 9313 in the provision of green space and the composition of species assemblages (Kotze, Venn, Niemelä, &
 9314 Spence, 2014). The European Union “Plan of Action on Subnational Governments, Cities and Other
 9315 Local Authorities for Biodiversity (2011-2020)” emphasizes the essential role of cities in achieving the

9316 Aichi Biodiversity Targets. Also the 7th Environment Action Programme supports the development of
9317 initiatives for the conservation of biodiversity.

9318 Urbanization has changed habitats, both spatially and through the release of heat, waste, nutrients
9319 and contaminants. Cities generate novel habitats and assemblages, as many species adapt to urban
9320 conditions, and urban habitats acquire characteristic communities. Disturbance is typical of urban
9321 habitats and they tend to remain at early to mid-successional stages, which can have high levels of
9322 species diversity. A number of the species that have become most adapted to cities originate in rocky
9323 habitats, such as the rock pigeon (*Columba livia*), the common swift (*Apus apus*) and the alpine swift
9324 (*Tachymarptis melba*) (Kelcey & Rheinwald, 2005). In Central Asia, the core urban avian fauna
9325 comprises 7 to 17 species (Fundukchiev 1987) with distinctive adaptive traits to urban conditions.

9326 Such novel features as green roofs and green walls have been introduced into many cities as potential
9327 means of enhancing the provision of supplementary habitats. Studies show that these can develop
9328 diverse assemblages of arthropods and vascular plants (Madre, Vergnes, Machon, & Clergeau, 2013),
9329 and they probably have the potential to support the biodiversity of some taxa.

9330 9331 Past and current trends

9332 As a result of intensive urbanization in the 20th and 21st centuries, patches of indigenous habitats have
9333 become fragmented, and many species have declined or disappeared. The overall result is generally a
9334 loss of species across most taxa, particularly specialized species, and a subsequent assemblage of
9335 mostly generalist species that are adapted to urban conditions.

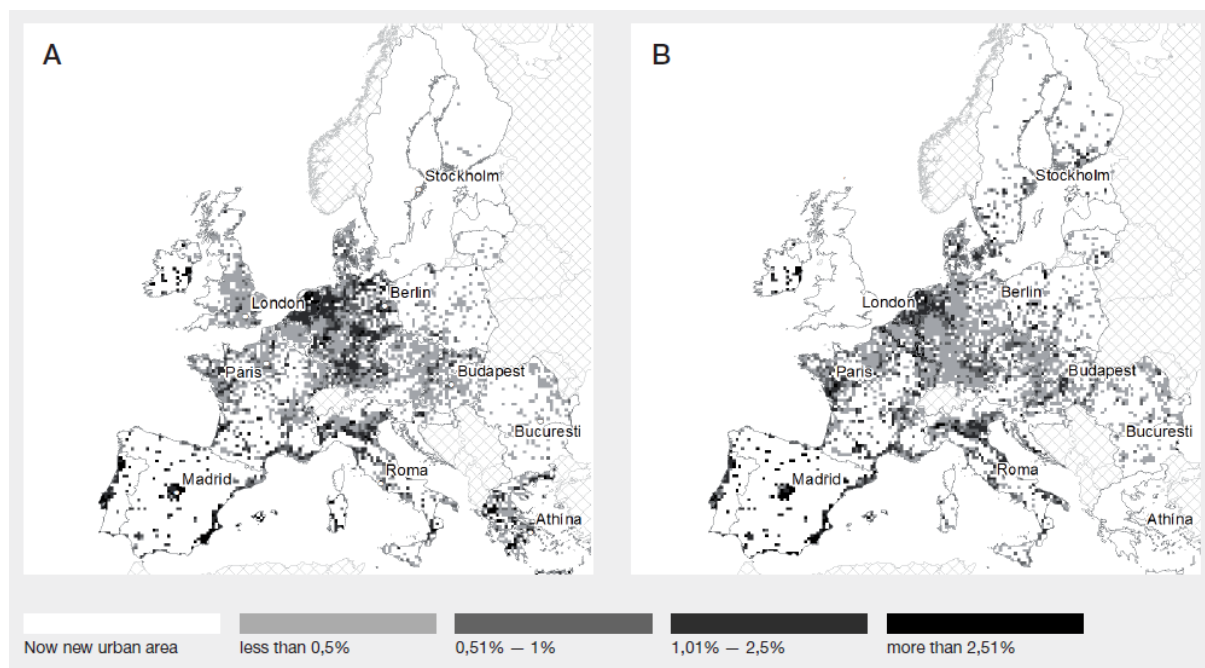
9336 Many species have adapted to urban conditions and are recognized as typical urban species. These
9337 include the European red fox (*Vulpes vulpes*) and feral pigeon (*Columba livia domestica*), and in Central
9338 Asia the common myna (*Acridotheres tristis*). In addition, many species have been periodically
9339 recorded as expanding into urban areas, such as the flying squirrel (*Pteromys volans*) in Helsinki
9340 (Mäkeläinen, De Knecht, Ovaskainen, & Hanski, 2016), the Eurasian eagle owl (*Bubo bubo*) in numerous
9341 cities (König & Weick, 2008) and the Eurasian lynx in Tallinn and Espoo. These probably result from
9342 declines in resources in peri-urban regions and availability of resources within urban regions.
9343 Vulnerable taxa, such as ground-nesting birds, do not persist in cities due to many threats.

9344 Fish species have declined in urban areas, with the loss of migratory species, such as salmon (*Salmo*
9345 *salar*), sturgeon (*Acipenser sturio*) and river lamprey (*Lampetra fluviatilis*), through fragmentation due
9346 to obstacles to free movement along rivers. Modification of rivers by straightening channels, dredging
9347 and canalizing, has resulted in the loss of species that inhabit or breed in gravel beds and river margins.
9348 Recently there have been initiatives in many cities to restore natural features of rivers, improve water
9349 quality and enhance connectivity. Some fish species that are present outside urban areas, such as three
9350 fish species endemic to the River Danube, *Gymnocephalus schraetzer*, *G. baloni* and *Zingel zingel*,
9351 which are all occasionally recorded in Budapest (Tóth-Ronkay et al., 2015), have potential to benefit
9352 from restoration of urban river systems.

9353 9354 Attribution of biodiversity trends to direct drivers

9355 There is a high level of impact of land-use change on both the extent of habitat and the biodiversity
9356 status. The loss, degradation and isolation of both terrestrial and aquatic habitats, is a major cause of
9357 declines in biodiversity. Habitat loss is mainly due to replacement of green space with urban
9358 infrastructure, and the conversion of indigenous habitats to managed habitats, such as parks and
9359 gardens (Kabisch & Haase, 2013). There is a high level of variation within the region (**Figure 3.17**)
9360 (Siedentop & Fina, 2012).

9361



9362

9363 **Figure 3.17: Patterns of annual change of urban land cover across 26 European countries for the**
 9364 **periods (a) 1990-2000 and (b) 2000-2006. Prepared from CORINE land-cover data and produced by**
 9365 **(Siedentop & Fina, 2012).**

9366 Habitat degradation includes qualitative changes in habitats that are not destroyed, but converted,
 9367 such as woodlands converted to parks, species-rich grasslands - to lawns, or water bodies that are
 9368 dredged, drained, canalized or diverted into pipes. Homogenization due to management practices
 9369 leads to loss of specialized species and domination of communities by a small number of generalist
 9370 species.

9371 Relict natural habitats such as steppe grasslands and limestone caves in Budapest (Tóth-Ronkay et al.,
 9372 2015) and calcareous sand dunes in Rotterdam (Van de Poel, De Baerdmaeker, Bakker, Moerland, &
 9373 De Zwarte, 2015), support communities of specialized species, though fragmentation often leads to
 9374 species losses and reduces the potential for re-colonization. Large old mature trees in parks, often
 9375 more common even than in mature forests, can provide nesting cavities for birds and support
 9376 communities of saproxylic insects (Venn et al., 2015) and fungi, such as polypores, though they have
 9377 been reduced in some cities for safety reasons. Such habitats may be lost outside cities and become
 9378 increasingly valuable for biodiversity (Gilbert, 1989), depending on their size and capacity to retain
 9379 characteristic species communities.

9380 Fragmentation and loss of connectivity is one major cause of biodiversity decline. Migratory species
 9381 such as the common frog (*Rana temporaria*), which migrates between running water, still water and
 9382 terrestrial habitats during its annual life cycle, are particularly vulnerable (Št'astný, Červený, Rom, et
 9383 al., 2015). Fragmentation and isolation of habitats results from the development of urban
 9384 infrastructure, particularly communication networks, such as roads, but can also include noise, light
 9385 and chemical barriers both within and between habitats (V. L. Vershinin, Vershinina, Berzin, & Zmeeva,
 9386 2015). Some cities retain large green space elements and extensive corridor networks, often following
 9387 the courses of rivers, such as riparian forests (Herrera et al., 2015).

9388 Climate change has less negative impacts in urban areas than in many other systems, as urban areas
 9389 are warmer, lighter and drier, and thus their assemblages tend to contain mainly thermophilic species.

9390 However, cities in northern parts of the region, such as Helsinki and Rotterdam, are experiencing an
 9391 ongoing influx of species of many insect taxa, including Lepidoptera, Carabidae, Odonata and Apidae,
 9392 as a consequence of range expansions due to climate change (Moerland, De Baerdemaeker, Boesveld,
 9393 Grutters, & Van de Poel, 2015; Venn et al., 2015).

9394 Pollution affects habitats and communities most intensively and extensively in urban regions.
 9395 Pollutants include heavy metals, pesticides, nutrients, salt, other chemicals, heat and light. In many
 9396 cities, legislation has been introduced to control pollution, with consequent decreases in their levels
 9397 in green infrastructure. Heavy metals are common in most urban soils, and lead levels can be high
 9398 adjacent to major roads, due to the use of lead in petrol fuels prior to the 1990s. Pesticide residues
 9399 (DDT, DDD, DDE, phosphorus organic-trichloroform) are present in high concentrations in suburban
 9400 regions of some eastern European cities (Peskova, 2000). Some rare plants, with tolerance to metals,
 9401 including a number of orchid species, occur at sites containing calcareous metalliferous spoils in the
 9402 UK (Johnson, Putwain, & Holliday, 1978). The urban heat island phenomenon can increase
 9403 temperatures by approximately 2–3 °C in the urban core (Vershini et al., 2015). In northern Europe,
 9404 many cities contain thermophilic species due to suitable microclimatic conditions. These include fish
 9405 and amphibians in aquatic habitats and also fig trees (*Ficus carica*), for instance, in some UK cities
 9406 (Gilbert, 1989). Thermal pollution can also result in phenological changes (Belimov & Sedalishchev,
 9407 1980; Fominykh & Lyapkov, 2011; Piano et al., 2017). High levels of light pollution, particularly in
 9408 Central and Western Europe (**Figure 3.18**) cause a disorientating effect on some nocturnally flying
 9409 insect taxa and can compromise pollination (Knop et al., 2017). Bats, amphibians and entomophagous
 9410 mammals use this niche, i.e. streetlights, illuminated buildings, for foraging. Recently there have been
 9411 initiatives to reduce the amount of energy used for lighting and the amount of light lost into the
 9412 atmosphere.

9413 Overexploitation in the urban systems is attributed to excessive utilization of recreational areas, which
 9414 can lead to erosion. Tourism pressure has also had an impact on vulnerable biotopes in the
 9415 Mediterranean region (Mansuroglu, Ortacesme, & Karaguzel, 2006). Land-use change, recreational
 9416 activities and the intensification of fish farming have also affected populations of amphibians, as has
 9417 the spread of the chytrid fungus *Batrachochytrium dendrobatidis*, which has devastated amphibian
 9418 populations in many parts of Europe and Central Asia (Štátný, Červený, Rom, et al., 2015; Tóth-
 9419 Ronkay et al., 2015).

9420 Alien and invasive species seriously affect ecological equilibria, and displace indigenous species or
 9421 hybridize with them (Rhymer & Simberloff, 1996). Urban sites are among the most invisable biomes
 9422 (Richardson & Pysek, 2006). Exotic species are a problem in most cities. Both escapes of garden plants
 9423 and the release of pets maintain alien species populations (Herrera et al., 2015). It has been estimated
 9424 that 2000 exotic species of arthropods were introduced to Europe during the 20th century (Kobelt &
 9425 Nentwig, 2008), mostly via cities. In the case of taxa introduced incidentally via anthropogenic activity,
 9426 such as spiders and other arthropods, the majority of these arrive via international trade (Kobelt &
 9427 Nentwig, 2008). Many cities have programmes for the control of alien invasive species, though a major
 9428 problem is the delay between recognition of invasiveness and initiation of control measures. Some
 9429 invasive plant species, such as *Elodea canadensis*, *Solidago canadensis*, or *Heracleum species* have
 9430 colonized virtually the whole of Europe. Invasive plant and tree species, such as *Robinia pseudoacacia*
 9431 and *Acer negunda*, also lead to homogenization of woodlands and loss of microhabitats and associated
 9432 communities.

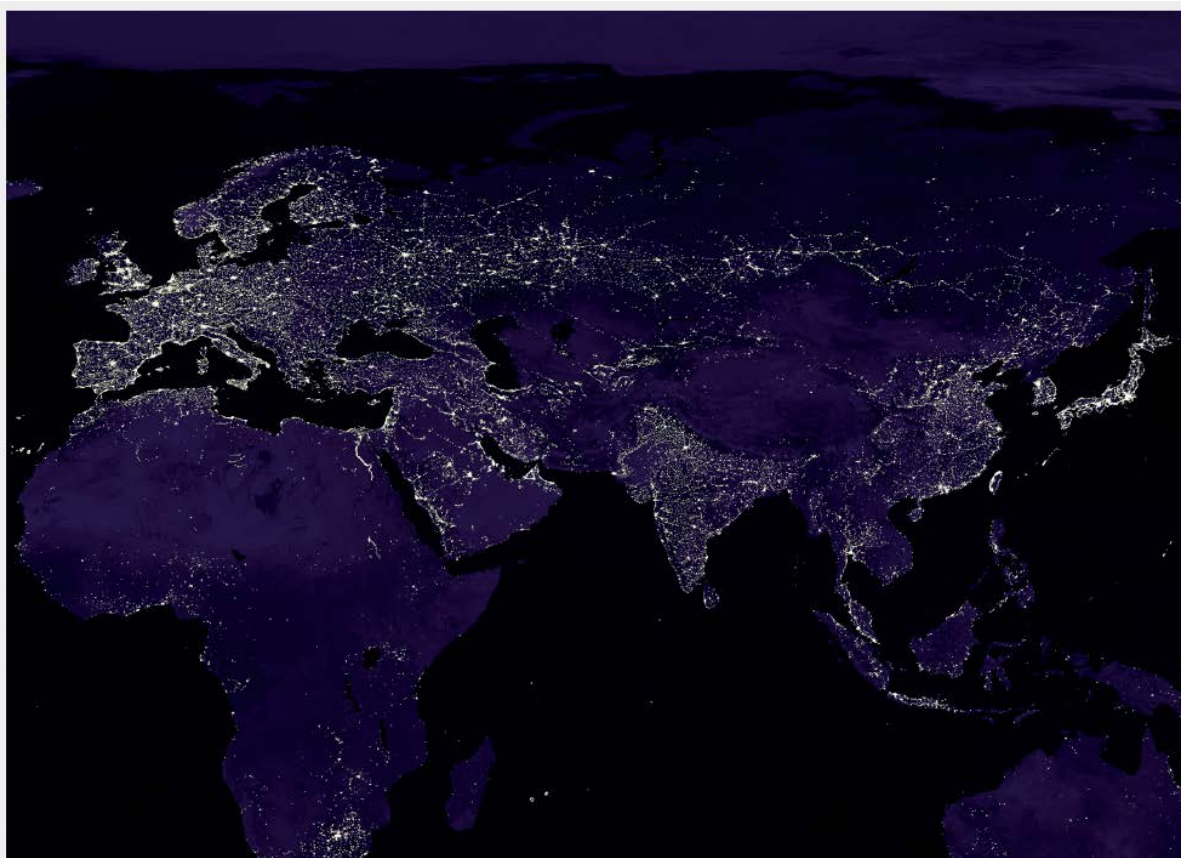


Figure 3.18: NASA satellite image of global city lights (2008) (Image by Craig Mayhew and Robert Simmon, NASA GSFC. Based on data from the Defense Meteorological Satellite Program)

In aquatic communities, introductions of alien fish species including carp (*Carassius* spp), rainbow trout (*Oncorhynchus mykiss*), silver carp (*Hypophthalmichthys molitrix*) and eel (*Anguilla anguilla*), reduce the potential for restoring indigenous communities (Červený, Rom, et al.; Herrera et al., 2015; Št'astný; 2015; Tóth-Ronkay et al., 2015).

Conservation initiatives

There are many cases of habitat and population restoration and species reintroductions in cities of Europe and Central Asia (McNeill, 2010). Many of these have been accomplished through EU LIFE actions. Many cities have biodiversity plans, or biodiversity incorporated into other strategic policy. There is ongoing encroachment of large areas of green space for development, due to the dwindling availability of suitable land for construction. Wetlands, rocky hills and other habitats have been conserved and many, such as the riparian forests of Dresden and Leipzig, have been protected (Haase & Gläser, 2009).

Parks and woodlands can also be valuable, and in many cities they are now managed less intensively, with retention of decaying wood for saproxylic species. Spider assemblages of cities are diverse and include a considerable number of species benefitting from humans and urban spaces (Fedoriak, Rudenko, Iaroshynska, & Zhukovets, 2012). Many of these are also present in green infrastructure and and some species have adapted to inhabiting buildings since the 1930s.

Lepidopteran species of meadows and open habitats, are particularly sensitive to urbanization, with poor levels of diversity in urban areas and higher diversity restricted to more natural areas at the periphery (Št'astný, Červený, Řezáč, et al., 2015). The decline of Lepidoptera has resulted from

intensive urban development, widespread use of pesticides during the post-war period and light pollution, which attracts and disorients males of nocturnal species (Manu et al., 2015). Many cities have had more diverse assemblages of Lepidoptera during the early 20th century (e.g. (Manu et al., 2015). Replacement of vegetation with solid surfaces is probably a major reason for this decline. River banks and remnant forest habitats still retain some noteworthy species, such as the ash hawkmoth (*Dolbina elegans*) in Bucharest (Manu et al., 2015).

Cities also provide opportunities through the allocation of municipal resources to conservation for the maintenance of urban biodiversity. This can include mowing and grazing of meadows for the benefit of plants and insects (Venn et al., 2015), management of wetland vegetation for amphibians (Št'astný, Červený, Rom, et al., 2015) and control of invasive species. This is particularly important for species that decline due to the cessation of suitable management regimes of semi-natural habitats. However, many of these are affected by landscape change on such a large regional scale that local initiatives alone do not have the capacity to improve the situation dramatically.

3.3.2.11 Special systems

3.3.2.11.1 Heathlands

Overview of the sub-system

Dwarf-shrub dominated heaths are among the principal cultural landscapes of the Atlantic regions of Western Europe (Janssen et al., 2016). These heathlands developed about 4000 years ago as a result of forest clearances, and have since been maintained by a land-use regime that may include year-round free-range grazing by domestic ungulates, prescribed burning, cutting of vegetation and turf for fuel, and harvesting of vegetation for fodder (Gimingham, 1972; Kaland, 1986; 2014 Odgaard, 1994; Jansen et al., 1997). Heathlands have since been an intrinsic part of the agricultural system, with the pattern and intensity of their use closely linked with the local agricultural economy (Diemont & Jansen, 1998; Kaland, 1986, Diemont et al., 2013).

Heathlands harbour unique landscape and habitat qualities and specialized biodiversity, and are thus of nature conservation interest (Janssen et al., 2016, Halada et al., 2011, Rosa Garcia et al., 2013, Halvorsen et al., 2015, Nybø and Evju, 2017, Webb et al., 2010). They support characteristic plant and animal assemblages (Webb, 1986), which respond to, and in part are dependent on, the interplay between traditional management practices and underlying environmental variability (vascular plants and bryophytes (Vandvik et al., 2005; Velle et al., 2014), carabid beetles (Bargmann et al., 2015), other insects (Wallis de Vries et al., 2016), and soil invertebrates (Ponge et al., 2015). The long-term land-use history of heathlands has also had evolutionary consequences, for example, *Calluna vulgaris* seed germination is stimulated by smoke in heathlands, a trait that is lacking in populations from other habitats not regularly subject to burning, such as alpine areas (Vandvik et al., 2014).

Past and current trends

Traditional management practices maintained open heathlands until the beginning of the 20th century. During their maximum extent (**Figure 3.19**) heathlands occurred over several million hectares, but today less than 350,000 ha remain (Diemont, Webb & Degn, 1996; Webb 1998).

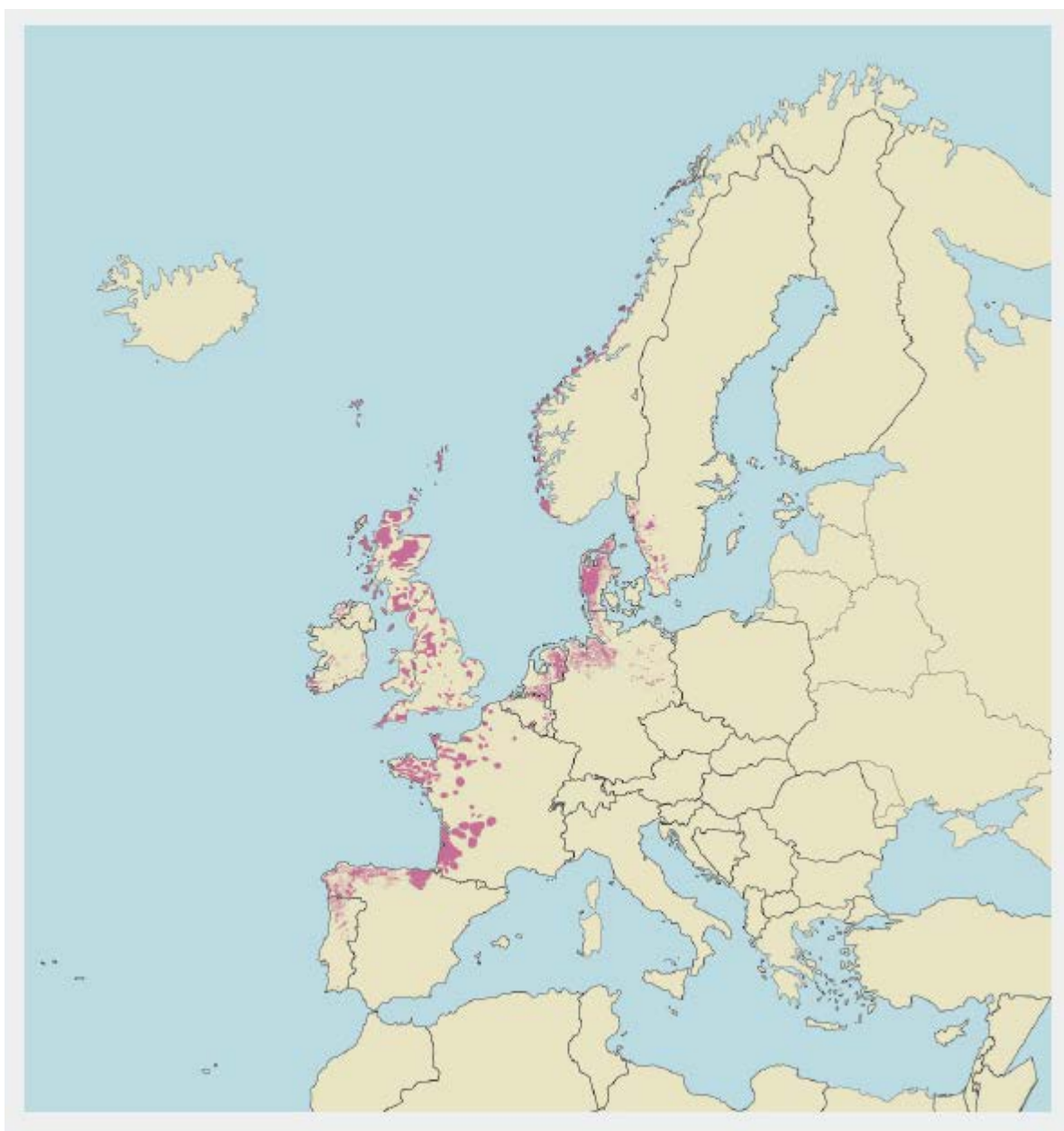
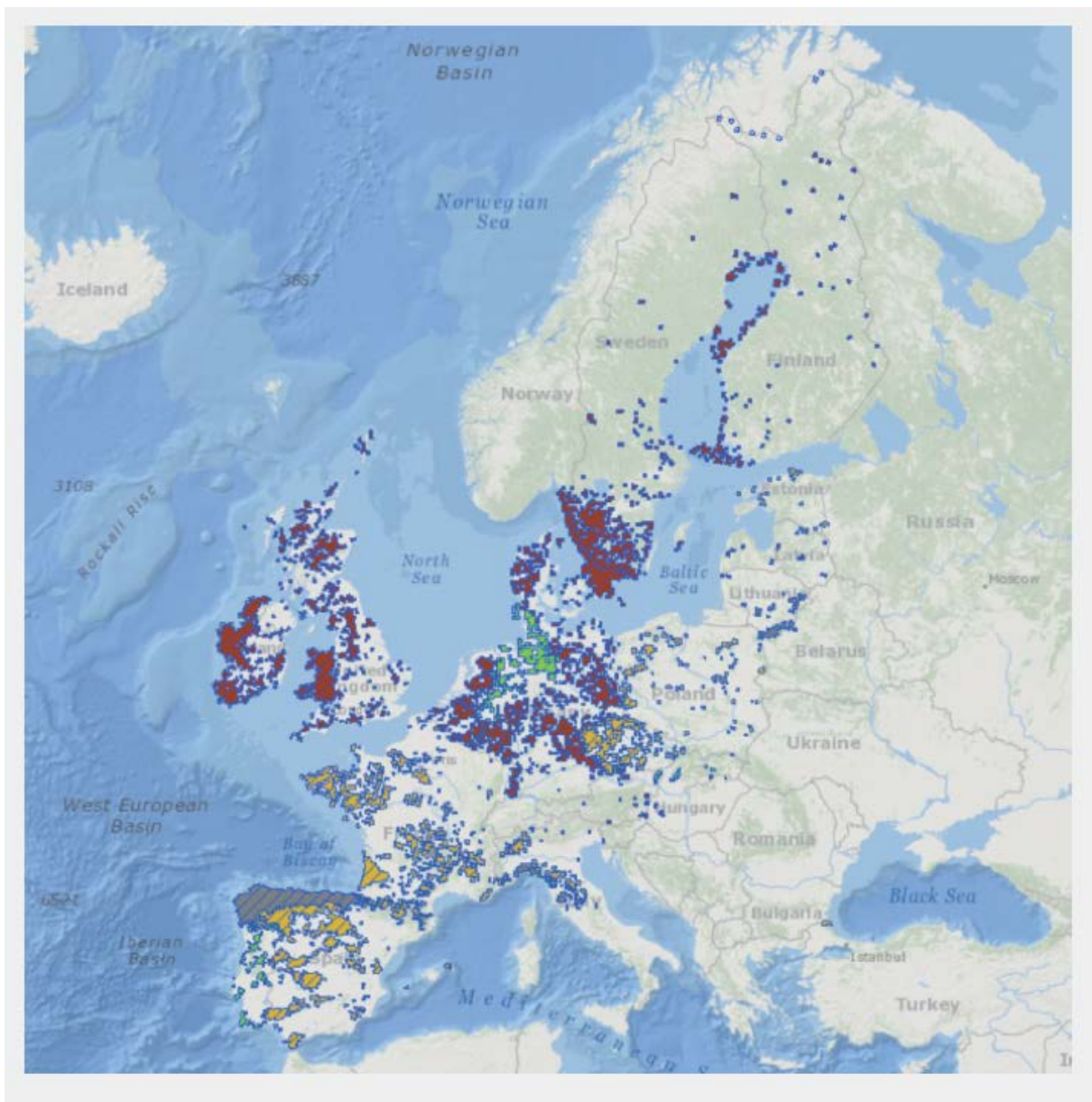


Figure 3.19. Distribution of lowland heathlands in Western and Central Europe during their maximum extent, ca. 1850. Source: Haaland, S. (2002).

The heathlands of Western Europe are now threatened throughout their range (<https://bd.eionet.europa.eu>; Lindgaard and Henriksen 2011). In the Mediterranean parts of Western Europe, major heathland habitat types (European Union habitat number 4010 - Northern Atlantic wet heaths with *Erica tetralix*, 4020 - Temperate Atlantic wet heaths with *Erica ciliaris* & *E. tetralix*, and 4030 - European dry heaths), are reported by European Union member States to be in “inadequate” conservation status. In the Continental, Boreal and Atlantic parts²⁵ these same habitats are reported to have “bad” conservation status. Dry Atlantic coastal heath with *Erica vagans* (Habitat 4040) is somewhat less threatened, its status being classified as “inadequate”. The European Red List of Habitats (Janssen et al., 2016) classifies some heathland types (F4.1 Wet heath and F4.2 Dry heath) as “Vulnerable”. Approximately one third of the latitudinal distribution of heathlands is found in Norway,

²⁵ Continental, Boreal and Atlantic parts of Western Europe as per EU Habitats directive

9510 which is not party to the Habitats Directive. The corresponding Norwegian Red List for ecosystems and
 9511 habitat types classifies northern coastal heathlands as “Endangered” (Lindgaard & Henriksen 2011,
 9512 **Figure 3.20**).



9513
 9514 **Figure 3.20: Distribution and conservation status of Habitat 4030 Dry Heaths across Europe. Green:**
 9515 **Favourable status. Grey: Unknown. Yellow: Unfavourable-Inadequate status. Red: Unfavourable-**
 9516 **Bad status. Note that heaths of countries not party to the Habitats Directive are not reported and**
 9517 **mapped in Eionet (<https://bd.eionet.europa.eu>).**

9518 Attribution of biodiversity trends to direct drivers

9519 Across their range in Western Europe, heathlands thus suffer from poor conservation status and loss
 9520 of biodiversity and ecosystem functions. The underlying drivers of these negative trends vary. Pollution
 9521 (especially atmospheric nitrogen deposition and associated acidification), land-use intensification, and
 9522 habitat loss or fragmentation are the main drivers in the central parts of the heathlands' range (Härdtle
 9523 et al., 2009; Aerts & Heil, 2013). Land abandonment and habitat conversion, including afforestation,
 9524 dominate in the southern, westernmost, and northern parts (Britton et al., 2017; Fagúndez, 2013;
 9525 Halvorsen et al., 2015; Nybø & Evju, 2017). Contrasting processes may drive changes within the same

landscape or region. For example, in the UK declines in the quality of lowland heaths have occurred due to increasing stocking in privately owned sites and succession towards woodland in areas managed for forestry or conservation (Diaz et al., 2013). In the uplands of the UK over-exploitation for sheep grazing is a critical concern (Pakeman & Nolan, 2009). In some important parts of heathland range future prospects are undermined by controversies over their ecological importance and the sustainability of management regimes (Figure 3.21) (Davies et al., 2016).

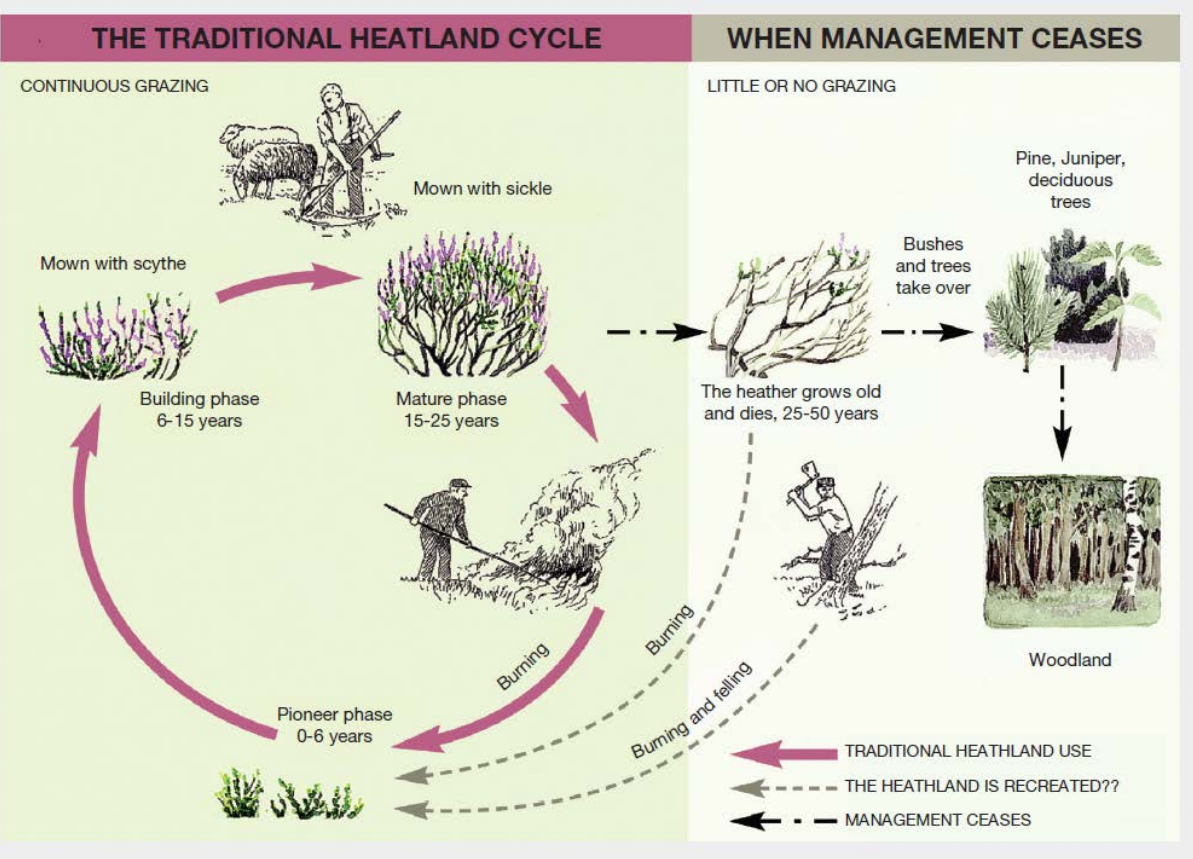


Figure 3.21. The traditional management cycle with prescribed burning, grazing, and mowing, and the successional dynamics occurring after abandonment of management in heathlands. Developed from Gimingham (1972).

3.3.2.11.2 Caves and other Subterranean Habitats

Overview of the sub-system

Subterranean habitats represent an extreme environment with unique particularities including trophic dependence on surface ecosystems. The relative constancy of abiotic factors makes these habitats and their associated fauna one of the most vulnerable on Earth to any disturbance (Juberthie, 2000). The absence of photosynthetic activity, limited supply of organic material, as well as stable temperature, high relative humidity and low rates of evaporation create an environment that determines the distribution and population density of cave fauna (Holsinger, 1988). Subterranean ecosystems encompass terrestrial and aquatic systems - the latter constituting freshwater, anchialine (with an underground connection to the ocean) and marine systems.

We distinguish to two types of subterranean systems, subterranean terrestrial systems (dry caves, epikarst, MSS (*milieu souterrain superficiel*)) and subterranean aquatic systems (flooded caves, groundwater, interstitial).

Typically, two main zones are recognized in the karst: epikarst (cutaneous zone, the surface; and soil and subcutaneous zone, the regolith and enlarged fissures) and endokarst (vadose zone, water unsaturated, and phreatic zone, water saturated) (Ford & Williams, 2007; Palmer, 1991). Karst systems provide heterogeneous habitats of interconnected cracks, fissures and drainages, filled with air or water. The karst process is polyphasic through geological time and related to the change of level of sea and landmass, so inactive (fossil) caves may be present at different elevations. Moreover, shallow subterranean habitats, as areas of habitable space that are less than 10 metres in depth beneath the surface (ranging from large areas such as lava tubes, to tiny areas such as cracks in cave ceilings or pore spaces in soil) have little in common with caves except for the absence of light and a specialized fauna with typical „cave“ morphology (Culver & Pipan, 2014).

Subterranean habitats and their fauna are extremely vulnerable and endangered mostly by anthropogenic influences (pollution, overexploitation of caves, changing of water regime, building of hydropower plants and dams) as well as climate changes. Ecological categories are defined as stygoxene and troglaxene (stygo- relates to aquatic and troglo- to terrestrial) species, which spend their complete life cycle in surface environments and are only accidentally found in subterranean habitats; stygobite and troglomite species, which spend their complete life cycle in subterranean environments; stygophiles and troglomiles may have several kinds of life cycles—some populations live in surficial habitats and others in subterranean habitats, or individual life cycles necessitate use of both surface and subterranean environments (Gibert & Deharveng, 2002).

By 2000, approximately 5000 obligate subterranean aquatic (stygobionts) and terrestrial (troglomionts) species from Central Europe had been described. 1200 had been described from Asia, 500 from Africa, and 1000 from North America (Gibert & Culver, 2005). Central Europe is both a hotspot of subterranean biodiversity and a hotspot of research into subterranean biology, both historically and at present (Deharveng et al., 2009). The Dinaric karst in the western Balkan Peninsula is a global hotspot of subterranean biodiversity, with more than 900 aquatic and terrestrial obligate subterranean species recorded (Sket, 2005). Troglomiotic beetles are considered the most important contributors to terrestrial subterranean biodiversity in most temperate karst regions, including the Dinaric karst, where they present about 42% of the terrestrial troglomionts (Sket, Paragamian, & Trontelj, 2004). Subterranean biodiversity in Europe is actually higher than on other continents as indicated by (Culver & Sket, 2000).

There are also visible geographic patterns within Western and Central Europe. The first one is a gradient in species richness with diversity decreasing from south to north and highest biodiversity within the mid-European high subterranean diversity ridge (**Figure 3.22**) for details see (Culver & Pipan, 2013).

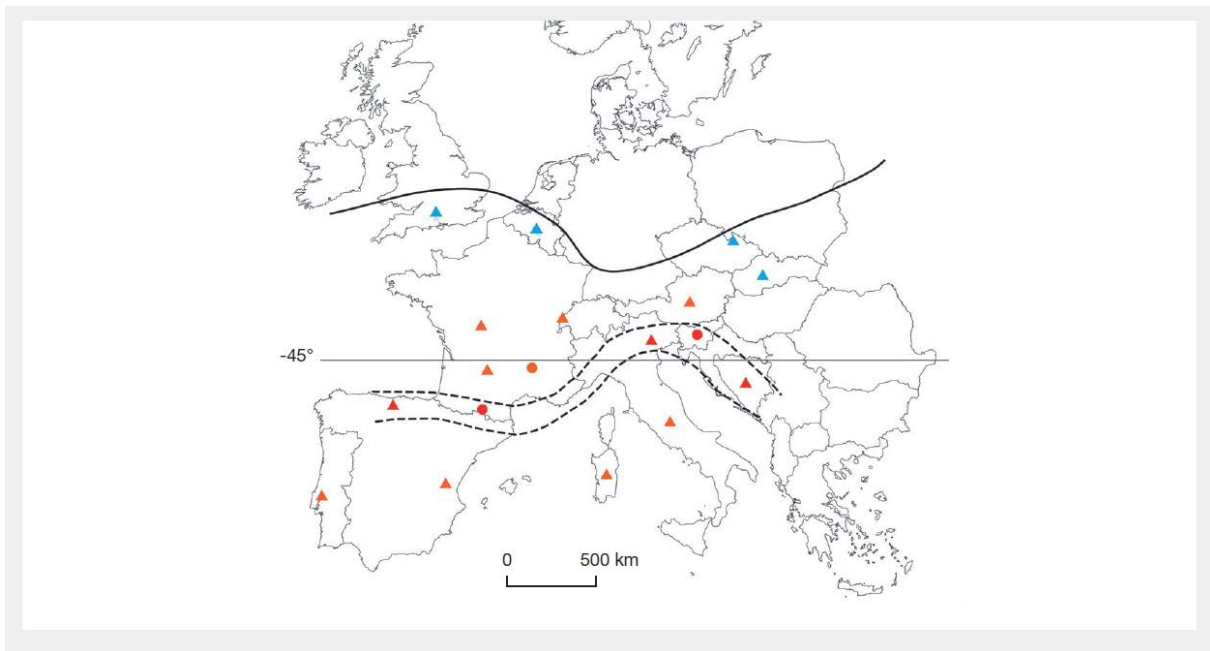


Figure 3.22: Map of species richness patterns of Western and Central European obligately subterranean terrestrial species (troglobionts). The blue triangles are areas with few if any troglobionts, the orange triangles are areas with fewer than 50 species, usually much fewer than 50, and the orange circle is Ardeche, with fewer than 50 species in 5000 km² of area or less. The red circles are the diversity hotspots in Slovenia and Ariege. Red triangles are other possible diversity hotspots. The boundary of the Pleistocene ice sheet is shown as a scored solid line. A pair of dashed lines indicates the hypothesized position of the high-diversity ridge. Adapted from (Culver et al., 2006; Culver & Pipan, 2013).

Some of the biodiversity hotspots are in the western Balkans (northeast Italy, Slovenia, Croatia, Bosnia and Herzegovina, and Serbia) and the Pyrenees (France and Spain). Increased diversity of stygobionts in the western Balkans could be explained by the complex biological and geological history of the Dinaric mountains (Sket, 1999) and complex history of the Mediterranean Sea (including its almost complete drying about 6 million years ago during the Messinian crisis, (Figure 3.23, Figure 3.24).

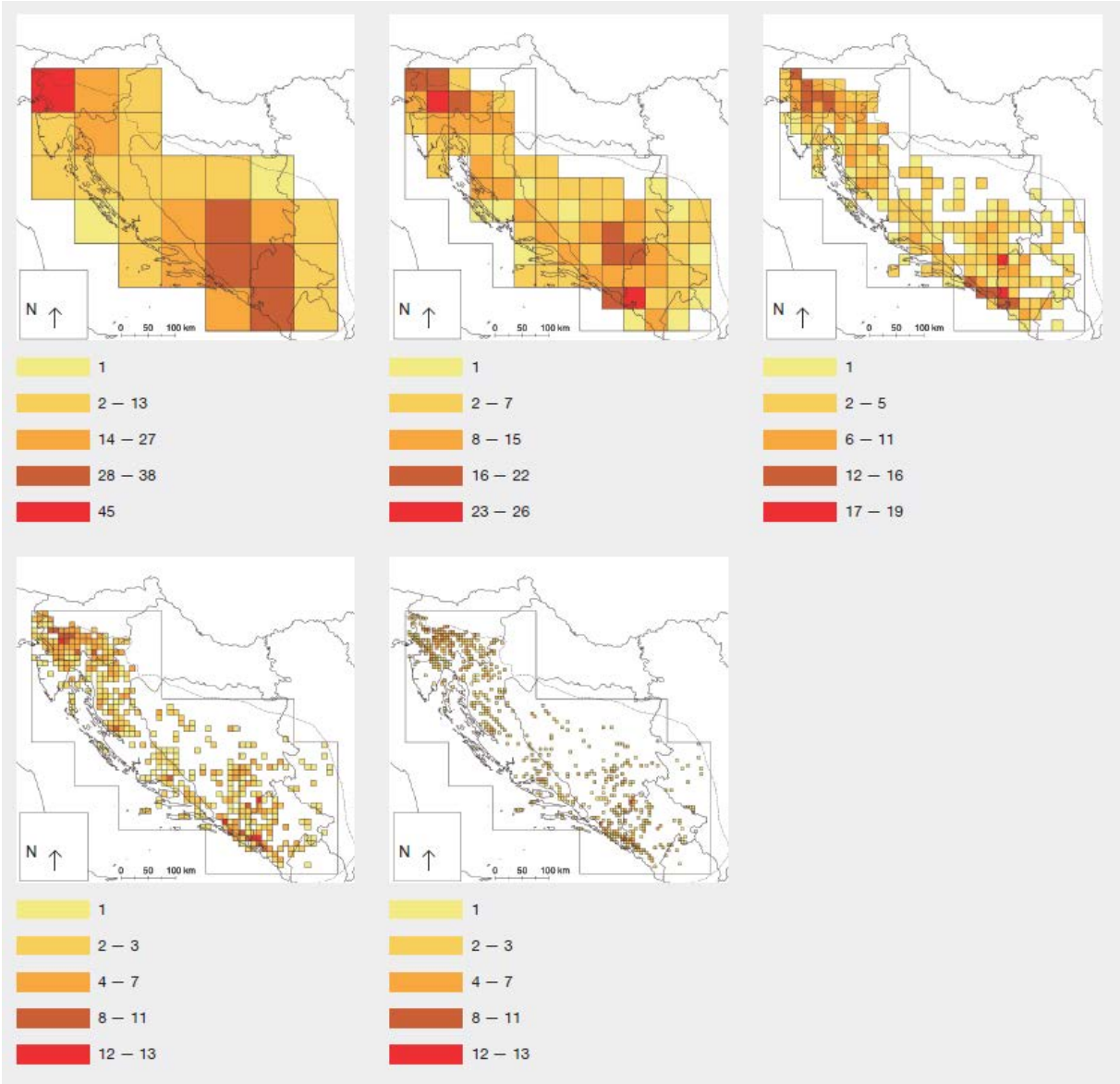


Figure 3.23: Distribution of the species richness of obligately subterranean terrestrial (troglobiotic) beetles in Dinaric karst at different grid cell sizes: (a) 80 x 80, (b) 40 x 40, (c) 20 x 20, (d) 10 x 10, (e) 5 x 5 km. Included are all records with localities of positional accuracy of 3 km or less, including 254 species (Lambert Conformal Conical Projection) (Zagmajster, Culver, & Sket, 2008).

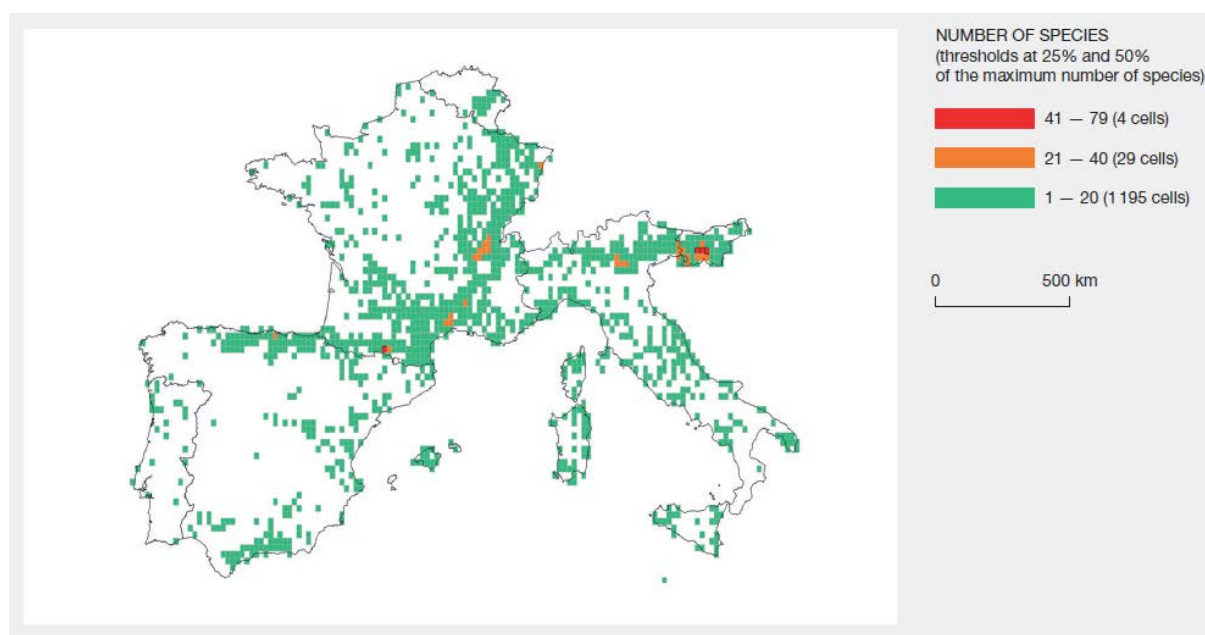


Figure 3.24: Map of obligately subterranean aquatic (stygobiotic) species numbers in 0.2 x 0.2 ° grid cells distributed across six Western and Central European countries (Deharveng et al., 2009).

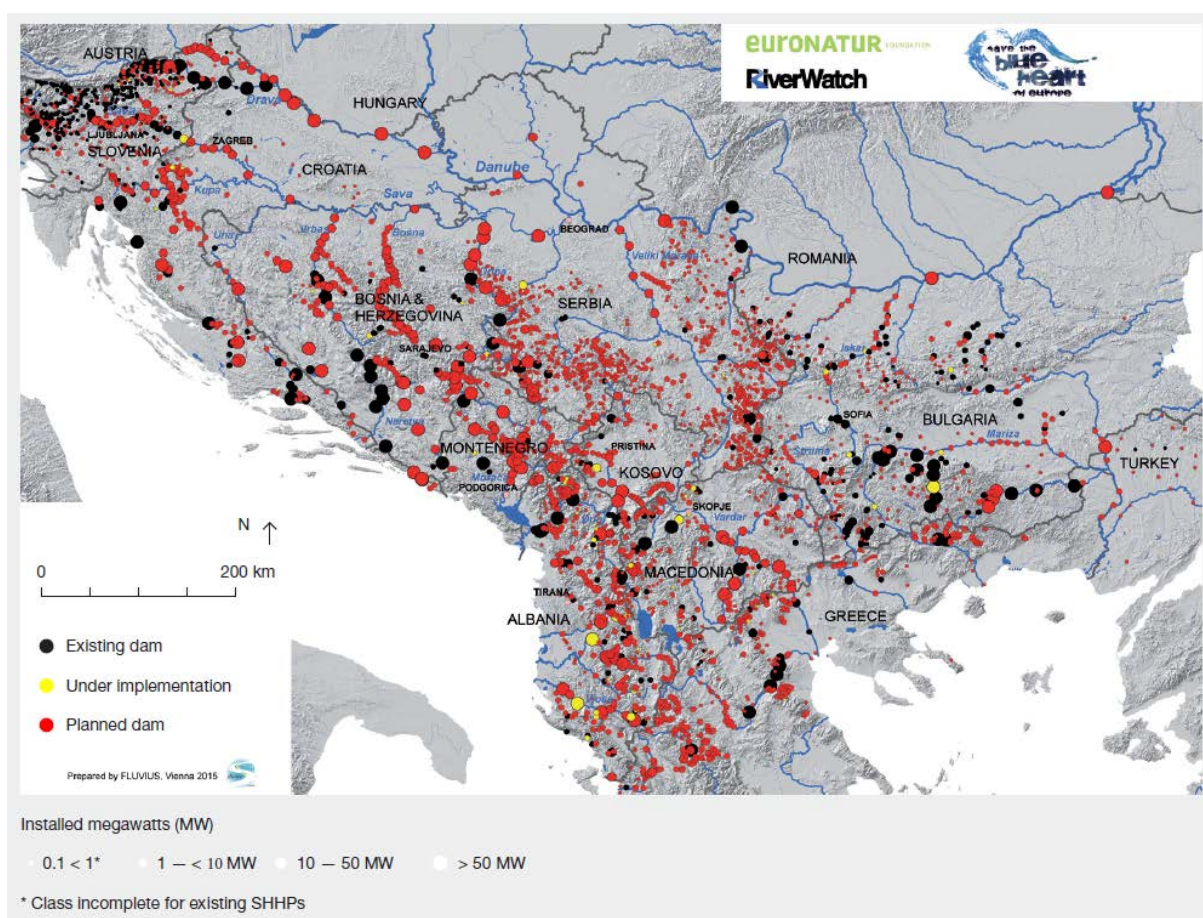
Population data are deficient compared with Western Europe, but information has recently improved for a few species, including olm *Proteus anguinus* (Trontelj & Zakšek, 2016), (Trontelj et al., 2009), chiropteran species (data collected by EUROBATS) and the bivalves *Congerius kusceri* and *C. jalzici* (Bilandžija, Čuković, & Puljas, 2014), (Jovanović Glavaš, Jalžić, & Bilandžija, 2017).

The Dinaric Arc is a habitat to one of the best-known representatives of stygofauna, the cave dwelling, blind salamander (olm; **Figure 3.25**). It is only found in the Dinaric karst region of the Balkan Peninsula (Italy, Slovenia, Croatia and Bosnia and Herzegovina; endemics of Dinaric karst) and is a globally vulnerable species (VU)(Arntzen et al., 2009). Its distribution is severely fragmented, and there is a continuing decline in the extent and quality of its habitat (underground aquifers) (Jelić et al., 2006; Sket, 2012). The olm is the largest strictly cave adapted (stygobiont) species in the World (23-25 cm) and, until recently, it was the only exclusively cave-dwelling vertebrate species found in Europe. Then, in 2012 the first cave loach (*Cobitis damlae*), was discovered in the Dalaman river drainage which flows into the karstic plain of western Turkey (Erkakan & Ozdemir, 2012).



Figure 3.25: Olm *Proteus anguinus*, an endemic species of Dinaric karst (Rupečica Cave in Ogulinsko Zagorje, Ogulin, Croatia, 2014); photo: Dušan Jelić.

9623



9624

9625 **Figure 3.26: Planned hydropower plants in Balkan Peninsula (Schwarz, 2012).**

9626 Impact of direct drivers on subterranean habitats and fauna

9627 In the nineteenth and early twentieth centuries, some animals were caught in large numbers for illegal
 9628 trading purposes (Sket, 2012). The trend of collecting and trading in rare and endangered fauna or
 9629 even paleontological samples (for example *Ursus speleous*) still persists (Lukić-Bilela, Ozimec,
 9630 Miculinić, & Basara, 2013).

9631 The main threats are habitat loss, water regulation and flooding, dam projects, overextraction,
 9632 quarries, and pollution. Moreover, due to a lack of research species are likely being lost before they are
 9633 even scientifically described.

9634 Shifts in water level regimes and seasonal cave flooding due mainly to hydropower development pose
 9635 extreme threats to underground ecosystems. More than 2,700 new hydropower plants are being
 9636 implemented or planned in the south of Central Europe (area of Balkan Peninsula) (**Figure 3.26**).

9637 Above-ground pollution was reported to seeps directly into the subterranean habitats and destroys
 9638 unique biodiversity (Danielopol, Griebler, Gunatilaka, & Notenboom, 2003; Slingenberg et al., 2009).

9639 Climate change impacts these fragile ecosystems through reduction of water in aquifers and lack of
 9640 seasonal flooding (Hunkeler, 2007). Cave temperature are generally strictly connected with the
 9641 external climate (Badino, 2004) and thus increase.

9642 Subterranean ecosystems are generally extremely oligotrophic habitats, receiving very little
 9643 degradable organic matter from the surface. Conversely, anthropogenic impacts on underground

ecosystems (for example from intensive tourism and recreational caving) cause important alterations to the whole subterranean environment. In particular, artificial lighting systems in show caves support the growth of autotrophic organisms (the so-called *lampenflora*), mainly composed of cyanobacteria, diatoms, chlorophytes and mosses (Mulec & Kosi, 2009)(Falasco et al., 2014).

3.3.2.12 Progress towards Multilateral Environmental Agreements for Terrestrial Ecosystems

European Union Biodiversity Strategy

The European Union Biodiversity Strategy Target 1 “Fully implement the Birds and Habitats Directives” and Target 2 “Maintain and restore ecosystems and their services” define actions to ensure habitats and ecosystems protection. According to the 2015 mid-term review of the implementation of the Strategy by the European Environment Agency progress toward these targets is insufficient: 15.6% of terrestrial habitat assessments in the period 2007-2012 had favourable conservation status; 3.3% had unfavourable, but improving trends; 36.7% had unfavourable, but stable trends; 28.8% had unfavourable and declining trends; 11.2% had unfavourable status with unknown trend relative to the period 2001-2006 and 4.3% have unknown status (Mid-term Review of the European Union Biodiversity Strategy, 2015).

At the same time the network of Natura 2000 sites has progressed and is largely completed for terrestrial habitats, since 2010 it has grown by 1,4% and in 2015 covered 18,1% of land in the European Union. Overall, the European Union biodiversity targets 1 and 2 will not to be fully met by 2020 should the rate of progress not improve.

Aichi Biodiversity Targets

Aichi Biodiversity Target 5 requires at least to halve the rate of loss of all natural habitats, including forests, and where feasible to bring it close to zero, and significantly reduce degradation and fragmentation. This is to be achieved through improvements in production efficiency and land-use planning, and enhanced mechanisms for natural resource governance combined with recognition of the economic and social value of ecosystem services provided by natural habitats (Nelson, E, et al, 2009, see Chapter 4). The emphasis for this target is specially made on preventing the loss of high-biodiversity value habitats, such as primary forests and wetlands. Recent evidence suggests that the rate of deforestation in Europe and Central Asia is decreasing (see 3.3), with some variations by country in Central Europe and Central Asia. Concerning terrestrial habitats, achievement of Target 5 is unlikely without increased implementation of integrated forest management targeted at conservation of biodiversity and without halting negative trends of biodiversity in agricultural and other areas in Europe and Central Asia.

The network of Natura 2000 sites has progressed and is largely completed for terrestrial habitats, covering about 18% of the land in Western Europe and Central Europe. Countries in Central Asia and Eastern Europe traditionally report on the coverage of strictly protected areas and do not account for other effective area-based conservation measures. In their national biodiversity strategies and action plans (NBSAPs) reports to the Convention on Biological Diversity Eastern European and Central Asian countries committed to achieve protected areas coverage by 2020 at the level of 12% in Eastern Europe and 15% in Central Asia, and at the level of 22% and 19% for all types of sustainably managed and protected terrestrial areas. Thus, Western and Central Europe has largely progressed toward achieving Aichi Biodiversity Target 11. Further, the implementation of the NBSAPs commitments of 2017 would allow for meeting Aichi Biodiversity Target 11 for terrestrial ecosystems in Eastern and Central Europe.

9689

9690

3.3.3 Inland surface waters

9691

3.3.3.1 Freshwater systems

9692

Overview of the system

9693 Freshwater habitat includes streams, rivers, lakes, ponds (temporary or not) and also their sources
 9694 (glaciers, aquifers or rainfall). Freshwater biodiversity includes organisms that either live permanently
 9695 in water, or spend part of their life cycle in water. The freshwater ecosystems of Europe and Central
 9696 Asia are very diverse. Based on the distribution and composition of freshwater fish species and major
 9697 ecological and evolutionary patterns, almost 60 different freshwater “ecoregions” were depicted for
 9698 this area (Abell et al., 2008). They include large rivers in the Atlantic, Arctic and Pacific Ocean basins
 9699 and the Mediterranean, Black, Caspian and Aral Sea basins. Lakes of different sizes are numerous in all
 9700 subregions with Lake Baikal in eastern Russia dominating in size and volume, containing almost 20%
 9701 of the world’s freshwater. Overall, almost 60% of world water volume stored in lakes is located in
 9702 Europe and Central Asia (Messenger, Lehner, Grill, Nedeva, & Schmitt, 2016). Out of four global
 9703 biodiversity hotspots identified for the region, the Mediterranean basin is considered a hotspot for
 9704 freshwater systems.

9705 Freshwater systems are consistently at higher risk than their terrestrial or marine counterparts
 9706 (Dudgeon et al., 2006) and the quantity and quality of habitats and abundance of many species is
 9707 declining in Europe and Central Asia. Agriculture is the biggest user of fresh water, constituting 70–
 9708 90% of the annual water demand for many countries (Rabalais et al., 2010), and this is expected to
 9709 further increase due to a growing population. In many regions, the lack of regulation of groundwater
 9710 extraction has led to a decline in water tables. If all of the water in a river is used by agriculture and
 9711 industry, leaving nothing for the aquatic environment, freshwater biodiversity will inevitably decline
 9712 and freshwater ecosystems will disappear. Of course, this crisis point is unlikely to happen if
 9713 technological solutions (e.g., change in farming practices, recycling waste water) are put in place to
 9714 close the gap between supply and demand. Climate change is expected to intensify the hydrological
 9715 cycle and alter evapotranspiration, with implications for ecosystem services but also feedback to
 9716 regional and global climates. As a result, increased stress on freshwater ecosystems is expected in the
 9717 coming decades.

9718 The overall diversity of freshwater species in Europe and Central Asia has routinely been reported to
 9719 increase towards lower latitudes, along with the proportion of threatened species. However, according
 9720 to Dehling *et al.* (2010), in Europe this pattern differs for lentic (standing water) and lotic (running
 9721 water) animal species. In Europe and Central Asia there is a high proportion of freshwater species with
 9722 unknown population trends, for example in the case of 76% of European freshwater fishes and 83% of
 9723 freshwater molluscs (Cuttelod, Seddon, & Neubert, 2011a). This highlights the urgent need for
 9724 monitoring and data collection across the region. However, according to Vörösmarty *et al.* (2010), the
 9725 highest incidence of freshwater biodiversity threats worldwide is for Europe and Central Asia and
 9726 correlates with the incidence of human water security threats.

9727

9728

Past and current trends

9729 Unfortunately, historical information and long-term data are rare for freshwater biodiversity and thus
 9730 the patterns of species richness, for example, are known with much less confidence than for terrestrial
 9731 systems (Carpenter et al., 2009; Strayer & Dudgeon, 2010; Tockner, K., Robinson, C. & Uehlinger, 2008;
 9732 Tockner, Pusch, Gessner, & Wolter, 2011). This lack of quantitative freshwater biodiversity data is
 9733 severe (e.g. 32% of IUCN evaluated freshwater invertebrate species in Europe are data deficient)

9734 especially for Central Asian freshwater ecosystems, as they have not yet benefited from IUCN Red List
9735 assessments.

9736 According to the State of the Environment Report review of the state of freshwater systems, only 53%
9737 of geographical Europe's rivers and lakes have a good ecological status in 2015 (EEA, 2015b) (Fig. 3.14),
9738 despite several major European water initiatives in the past 15 years. Ecological status is a criterion for
9739 the quality of the structure and functioning of surface water ecosystems. Based on current freshwater
9740 biodiversity trends, it is highly unlikely that Europe and Central Asia will achieve the relevant Aichi
9741 Biodiversity Targets by 2020 (i.e. Targets 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14) or Target 1 of the European
9742 Union Biodiversity Strategy. Furthermore, several water bodies in the region are drastically declining
9743 in size, and many ponds and streams are even disappearing from the landscape as a consequence of
9744 agricultural intensification, draining, dam construction and urbanisation in combination to climate
9745 change (Human Development Report 2015; Jeppesen et al., 2015; Bagella et al., 2016; Bogatov and
9746 Fedorovskiy, 2016; Boix et al., 2016). Examples of water bodies disappearing are particularly found in
9747 the Mediterranean region and Central Asia (Erik Jeppesen et al., 2015). An example is Lake Akşehir,
9748 which was previously one of the largest freshwater lakes in Turkey, but completely disappeared due
9749 to loss of surface and ground water sources through intensive crop irrigation of (Doğan, n.d.; Jeppesen
9750 et al., 2009).

9751 In the Mediterranean region, there is sometimes no legal requirement for a permanent minimum
9752 water outflow from dams and this often has dramatic consequences in summer when rivers dry out
9753 downstream (Benejam et al., 2016; Freyhof, 2011).

9754 A further issue of concern is the conservation of ponds in Europe and Central Asia at landscape scale,
9755 which harbour a significant proportion of aquatic biodiversity but are under increasing pressure. They
9756 have been historically neglected particularly in the Mediterranean region (Boix et al., 2016; Céréghino,
9757 Biggs, Oertli, & Declerck, 2008) and remain excluded from the provisions of the European Union Water
9758 Framework Directive. Natural wetlands (marshes and bogs) decreased by 5% between 1990 and 2006,
9759 one of the largest proportional land cover change of all habitats (EEA, 2010). In the Mediterranean
9760 region, temporary ponds contain rare, endemic or Red Data List species and as such form an
9761 irreplaceable type of habitat for a variety of freshwater biota (Céréghino et al., 2008). However, the
9762 shallowness and small size of many temporary ponds have made them very vulnerable to human
9763 impacts as they can easily be drained for agriculture, urbanization, tourism, or industrial purposes (Boix
9764 et al., 2016; Zacharias, Dimitriou, Dekker, & Dorsman, 2007). Moreover, annual rainfall has been
9765 declining substantially since 1900 in several parts of the Mediterranean region owing to climate
9766 change, and already dry periods in rivers and wetlands have been markedly prolonged.

9767 European Union member States reporting under the Habitats Directive indicate that 17% of Europe's
9768 freshwater habitats have an 'unfavourable to bad' conservation status, while 56% were classified as
9769 'unfavourable to inadequate' (EEA, 2015b). In the case of wetlands (mires, bogs and fens) the situation
9770 is much worse, with some 51% classified as 'unfavourable to bad' and another 34% as 'unfavourable
9771 to inadequate' (EEA, 2015b), (**Figure 3.27**). Yet relatively unaffected parts of the European Union
9772 include parts of the Balkans which, although not devoid of pressures, are freshwater biodiversity
9773 hotspots of continental and global value (Griffiths, Krystufek, & Reed, 2004). Concerning species, 30%
9774 assessments have an 'unfavourable to bad' conservation status and 45% assessments were classified
9775 as 'unfavourable to inadequate' (EEA, 2015b). For Eastern Europe, fresh water quality remains
9776 poor, with variation from contaminated to extremely polluted for the majority of large rivers in Russia
9777 (Minprirody of Russia, 2016). In Central Asia in mountainous regions water bodies were assessed
9778 as clean and even very clean, when in lowlands they were assessed as moderately polluted and
9779 sometimes as extremely polluted (UNECE, CAREC, 2011).

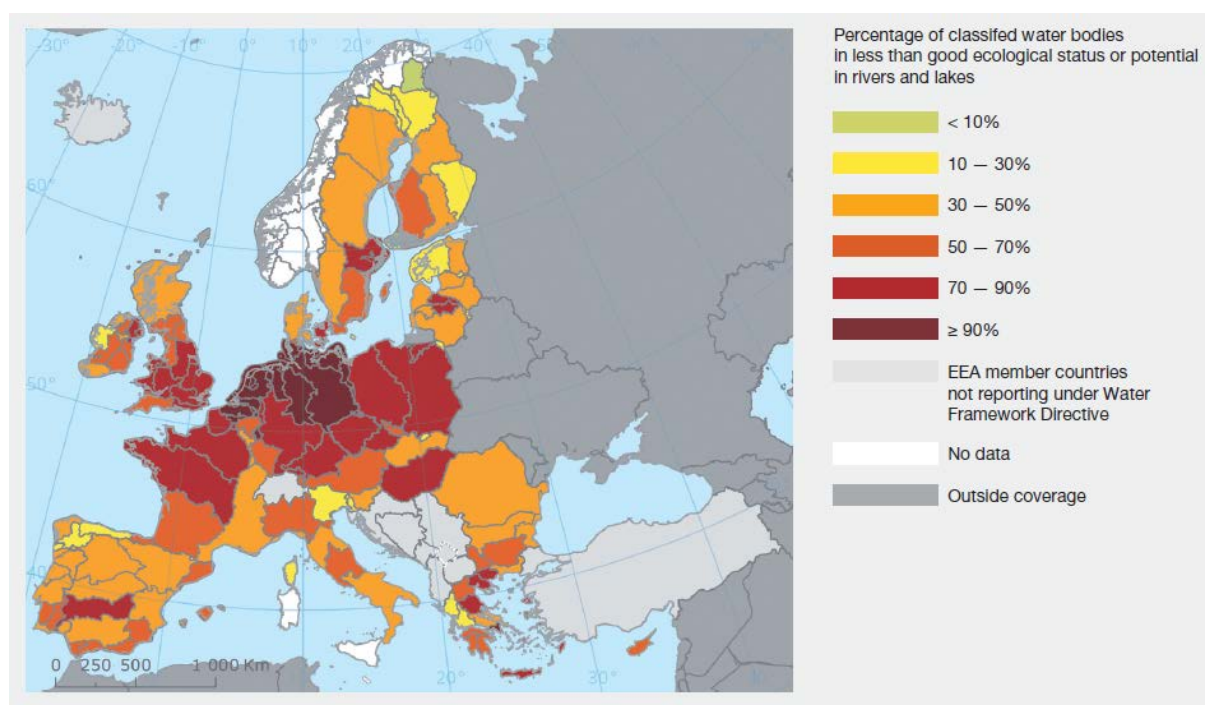


Figure 3.27: State of Western and Central European rivers and lakes. Good ecological status is defined “slightly” differently than high ecological status (with no or minimal human impact) and represents the target value that all surface water bodies have to achieve in the near future (EEA, 2015b).

Increased air temperatures result in melting of the glaciers which feed rivers and streams of Central Asia (e.g. Amu Darya, Syr Darya), causing changes in their hydrological regime (ZEN, 2009). Many formerly perennial wetlands are now seasonal, while several formerly seasonal wetlands are now rarely flooded. In other parts of Europe and Central Asia, recent climate change has produced contrasting trends. For example, floods in the Arctic Ocean basin are becoming more prevalent due to an increase in winter runoff over the past 30 years, underpinned by the melting of Central Asian glaciers (Georgievsky, 2016; Gurevich E., 2009). The Central Asian subregion also suffers from a drastic water loss that constitutes over 70 % of global net permanent water loss. This water loss is due a combination of drought and human activities including river diversion, damming and unregulated water intake (Pekel, Cottam, Gorelick, & Belward, 2016). In addition, in the southern Caucasus and in Central Asia, there is a decline in surface water quality due to poor water treatment facilities. This leads to an increase in organic pollution, with about 20% of untreated sewage directly discharged into rivers (Barenboim, Danilov-Danilyan, Gelfan, & Motovilov, 2013; Georgiadi, Koronkevich, Milyukova, & Barabanova, 2014). Freshwater salinization is also a threat across Europe and Central Asia (Cañedo-Argüelles et al., 2016; Jeppesen et al., 2015), however, it is most relevant for the arid parts of Central Asia and the Mediterranean region due to irrigation and land washing salt pollution (Crosa et al., 2006; Jeppesen et al., 2015; Karimov, Kamilov, & Matthies, 2014)). The lack of international and inter-sectoral coordination (e.g. between the irrigation and energy sectors) of water resource management in Central Asia and the Caucasus in the construction of irrigation systems, canals and water storage reservoirs in the lower reaches and deltas of the Central Asian Amu Darya, Kura, Syr Darya, Hrazdan and Ural Rivers has resulted in a severe environmental crisis (Petr, Ismukhanov, Kamilov, Pulakhton, & Umarov, 2004). Overall, despite contrasting trends in the availability of water resources in part of Europe and Central Asia (i.e. drying of ponds, flooding of rivers), the resulting environmental trend is a rapid decline in freshwater habitat quality and the decline in the most fragile species.

According to a recent study that identified the most important catchments for the conservation of freshwater biodiversity in geographic Europe (see Carrizo et al., 2017), protected areas do not currently provide sufficient coverage to the most important “critical catchments” (i.e. catchments that contain sites likely to qualify as freshwater “key biodiversity areas”) (Figure 3.28). Without improvement to the current configuration and perhaps management, European countries are unlikely to meet international obligations to reverse the loss of freshwater biodiversity.

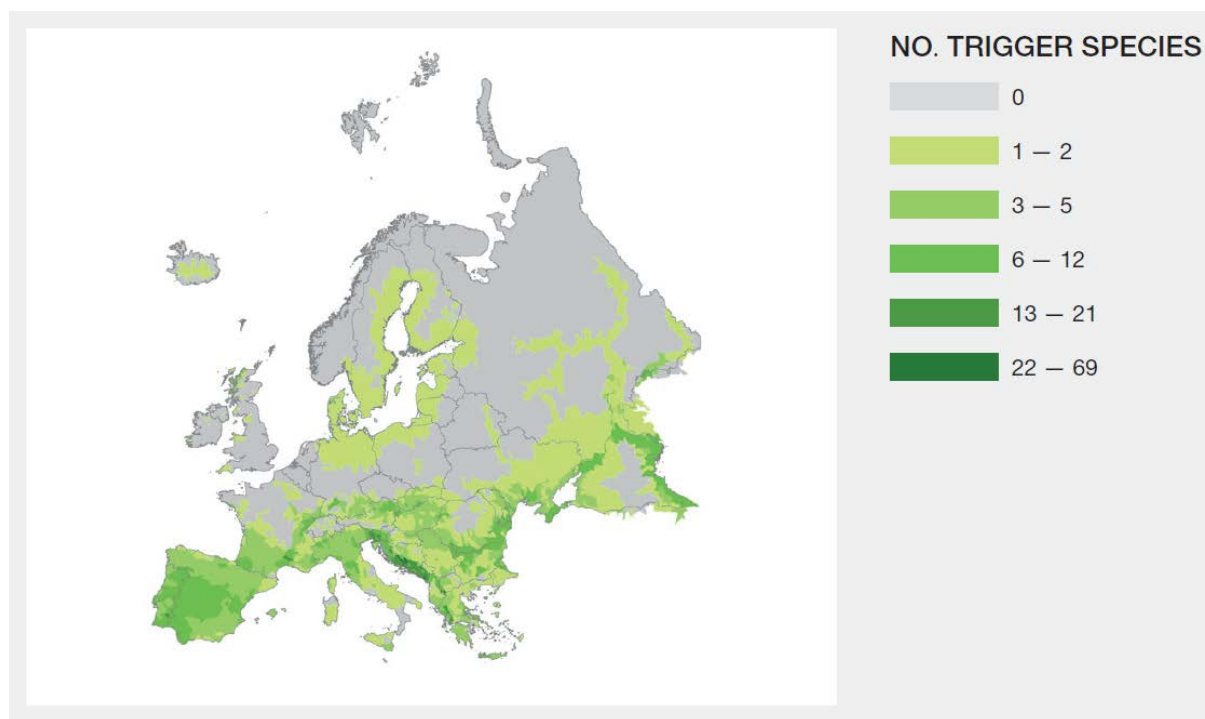


Figure 3.28: Critical catchments (i.e. catchments that contain sites likely to qualify as freshwater “key biodiversity areas”) for fishes, molluscs, odonates and aquatic plants, with 706 catchments shaded by the number of distinct trigger species.

Alien species trends

The rate at which alien freshwater species have been introduced in Europe and Central Asia has doubled in the space of 40 years, with the principal motives being aquaculture (39%) and improvement of wild stocks (17%) (EC, 2014; Gozlan, 2008a, 2015). Most sought-after freshwater species have already been introduced in Europe and Central Asia rivers and lakes and have contributed to biotic homogenisation (Gozlan, 2016; Vilà and Hulme Editors, 2017). In Central and Western Europe, 16% of lakes contain alien fish species (Jeppesen, Winfield, et al., 2017). The role of alien species in the emergence of novel diseases in the region has clearly been demonstrated in the last three decades through the increased geographic distribution of pathogens and parasites and also as facilitators of host-switching (Peeler, Oidtmann, Midtlyng, Miossec, & Gozlan, 2011). In the European Union, the historical trends of alien species introduction have been slowed down due to legislation (European Commission, 2007) concerning use of alien and locally absent species in aquaculture. This regulation establishes a “framework governing aquaculture practices to assess and minimize the possible impact of non-native species on aquatic habitats and in this manner contributes to the sustainable development of the sector”.

Attribution of biodiversity trends to direct drivers

Analyses of data on freshwater biodiversity show that more than 75% of Europe and Central Asia catchment areas are subject to multiple pressures and have been heavily modified, resulting in serious threats to their biodiversity (EEA, 2010; Tockner, K., Robinson, C. & Uehlinger, 2008). General threats to inland water ecosystems such as overexploitation, water pollution, flow modification, habitat degradation, invasive alien species and salinization (Dudgeon et al., 2006), are also the most relevant for Europe and Central Asia. Vörösmarty *et al.* (2010) have classified the importance of these drivers for biodiversity status and have shown that the main drivers threatening biodiversity in areas where incident threat is greater than the 75th percentile (i.e. most of the region), is water resource development (e.g. dams, river fragmentation), followed by pollution (e.g. organic pollution and sediment loading). In comparison, the effects of fishing and aquaculture pressure remain relatively limited, while the impact of alien species is projected to increase in the future (EEA, 2015f). This is further illustrated by another recent study at continental scale based on 4,000 monitoring sites across Europe (Malaj et al., 2014) which showed that the health of almost half of all European freshwater ecosystems are at risk from toxic organic chemical pollution. The chemical risk to freshwater ecosystems is strongly influenced by human land use, with areas of natural vegetation at significantly lower risk. Pollution pressures particularly affect central and north-western parts of Western European areas with intensive agricultural practices and high population density. Notably, the chemical status of 40% of Europe's surface waters remains unknown (EEA, 2015b) and a good chemical status (as defined by the European Union Water Framework Directive in terms of compliance with all quality standards established for chemical substances at European Union level) was not achieved in surface water bodies in 22 member States in 2015. Furthermore, although in most parts of Europe the potential for hydropower is almost fully exploited, the Balkans, which are a freshwater biodiversity hotspot of continental and global value, rank under the top world regions concerning planned dams and impoundments (Griffiths et al., 2004; Zarfl, Lumsdon, & Tockner, 2015). The boom in hydropower development threatens the remaining free-flowing rivers and near-natural freshwaters including in Siberian rivers (Saltankin, 2012). Similarly, according to current plans, Turkey's rivers and streams will see the construction of almost 4,000 dams, diversions, and hydroelectric power plants for power, irrigation, and drinking water by 2023 (Şekercioğlu et al., 2011).

According to the State of the Environment Report 2015's (EEA, 2015b) review of the health of freshwater systems in Western and Central Europe, the pressures reported to affect most surface water bodies are pollution from diffuse sources, in particular from agriculture, causing nutrient enrichment. More than 40% of rivers and coastal water bodies and more than 30% of lakes and transitional waters in European Union subregions are affected by diffuse pollution from agriculture (EEA, 2012). Between 20% and 25% are subject to point source pollution, for example, from industrial facilities, sewage systems and wastewater treatment plants. Across Europe and Central Asia, industrial and agricultural developments also influence water quality and threaten biodiversity in some highly diverse ecosystems (e.g. Selenga River and Lake Baikal in eastern Russia) (Sorokovikova et al., 2013). Nevertheless, pollution and nutrient enrichment are the only pressures that are reported to be decreasing in part of Western and Central Europe (EEA, 2015b; Jeppesen et al., 2005). Agriculture is the main reason for groundwater over-abstraction, an activity that is frequent in areas with low rainfall and high population density, and in areas with intensive agricultural or industrial activity, such as Italy, Spain, Greece and Turkey, among others. The result is sinking water tables, empty wells, draining of wetlands, higher pumping costs and, in coastal areas, the intrusion of saltwater from the sea which degrades the groundwater (Rabalais et al., 2010). Climate change and other components of global change, such as a growing population demanding higher food production, are expected to intensify these problems. Global warming can also exacerbate the symptoms of eutrophication in lakes and thus

9883 lower nutrient loading will be needed in a future warmer world to achieve the same ecological status
 9884 as today (Jeppesen, Søndergaard, & Liu, 2017).

9885
 9886 *Invasive alien species*

9887 Although increasing with the number of introductions, the risk of ecological impact after the
 9888 introduction of an alien freshwater fish species is less than 10% for the great majority of alien
 9889 freshwater species introduced (Gozlan, 2008b). However, alien species are very numerous in many
 9890 freshwater bodies (Altermatt et al., 2014) there are specific threats associated with the introduction
 9891 of freshwater species which clearly need to be mitigated, such as the risk of alien pathogen
 9892 introductions (Peeler et al., 2011) and alien species that have been clearly identified as ecosystem
 9893 engineers. The heightened risk associated with these species is that they are especially difficult to
 9894 eradicate (Cacho, Spring, Pheloung, & Hester, 2006) and capable of significantly altering the
 9895 functioning of ecosystems.

9896

9897 *3.3.3.2 Enclosed seas and saline lakes*

9898 ***The Aral Sea***

9899 Overview of the system

9900 In the mid-twentieth century, the Aral Sea was the fourth largest lake in the world with an area of
 9901 67,499 km² (Aladin and Plotnikov, 2008) and water volume 1,064 km³ (Glazovsky 1990). The
 9902 biodiversity of this moderately saline (around 10 g/l salt) lake (Dobrovolskii and Zalogin, 1982) included
 9903 about 200 species of invertebrates (Plotnikov, 2016), 34 fish species (Aladin and Plotnikov, 2008;
 9904 Ermakhanov et al., 2012; Zonn et al., 2009), and 30 species of macrophytes (Zhakova, 2013).

9905 The Aral Sea is, however, now a much smaller and more saline body of water **Figure 3.29**. Salt-dust
 9906 and sandstorms originating from the desiccated seafloor are affecting agricultural systems and the
 9907 livelihood and health of the people in the region (Breckle, Wucherer, Dimeyeva, & Ogar, 2012). Full
 9908 restoration of the Aral Sea in the foreseeable future appears impossible (Micklin, 2007).

9909

9910 Past and current trends

9911 From the 1960s, the Aral began to shrink because of large-scale water extraction from the two main
 9912 in-flowing rivers, the Amu Darya and the Syr Darya (Boomer, Aladin, Plotnikov, & Whatley, 2000). The
 9913 sea split into two isolated lakes, the Small and Large Aral Lakes. By 1989 the Large Aral Sea divided
 9914 further into Western and Eastern parts (Aladin and Plotnikov, 2008). By 2014, the eastern part of the
 9915 Large Aral Sea had dried completely, but later some water appeared again (**Figure 3.29**) (Lindsey, 2016;
 9916 NASA Earth Observatory, 2014). Climate changes have also contributed to transformation of the Aral
 9917 Sea (IPCC, 2014b).

9918 The desiccation of the Aral is considered the world's worst aquatic ecology crisis in recent history (Jean-
 9919 François Pekel, Cottam, Gorelick, & Belward, 2016). Negative effects of the Aral's retreat on the
 9920 ecology, economy, and quality of human life in the region are manifold and dramatic (Micklin, 2007;
 9921 Zavalov, 2005).

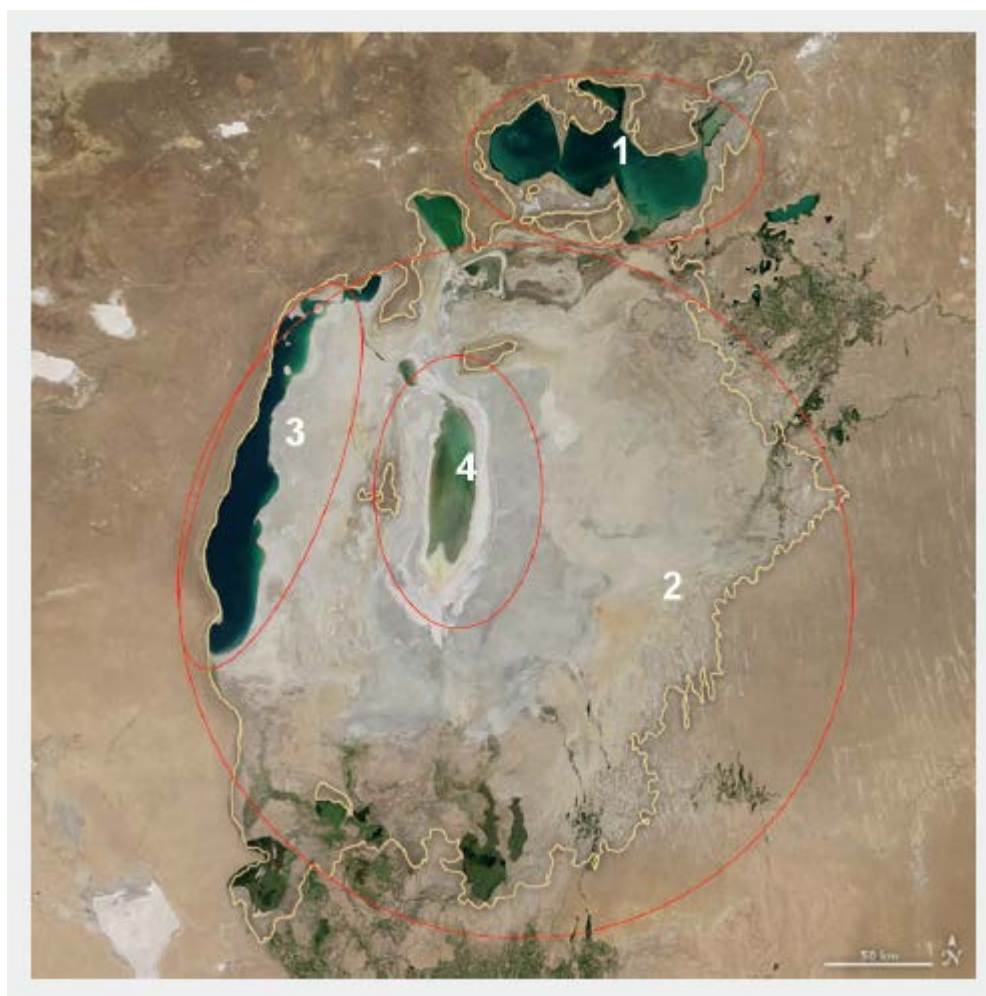


Figure 3.29: NASA's image: shrinking of the Aral Sea (Lindsey, 2016) . 1 – Small Aral; 2 – Large Aral; 3 – Western Aral; 4 – Eastern Aral. The fine line shows the approximate shore line 1960.

A dam separating the Small Aral basin from the Large Aral basin has resulted in an increase in the water level and decrease in salinity of the Small Aral. As a result the biodiversity of invertebrates has increased (Plotnikov, 2016). The Small Aral was stocked with fish and now even provides some commercial fish yields. The Large Aral Sea has split to several hypersaline lakes with biodiversity limited to species which are tolerant to high salinity, with a few species of invertebrates (Plotnikov, 2016) and macrophytes (Zhakova, 2013), but no vertebrates (Aladin et al., 2017).

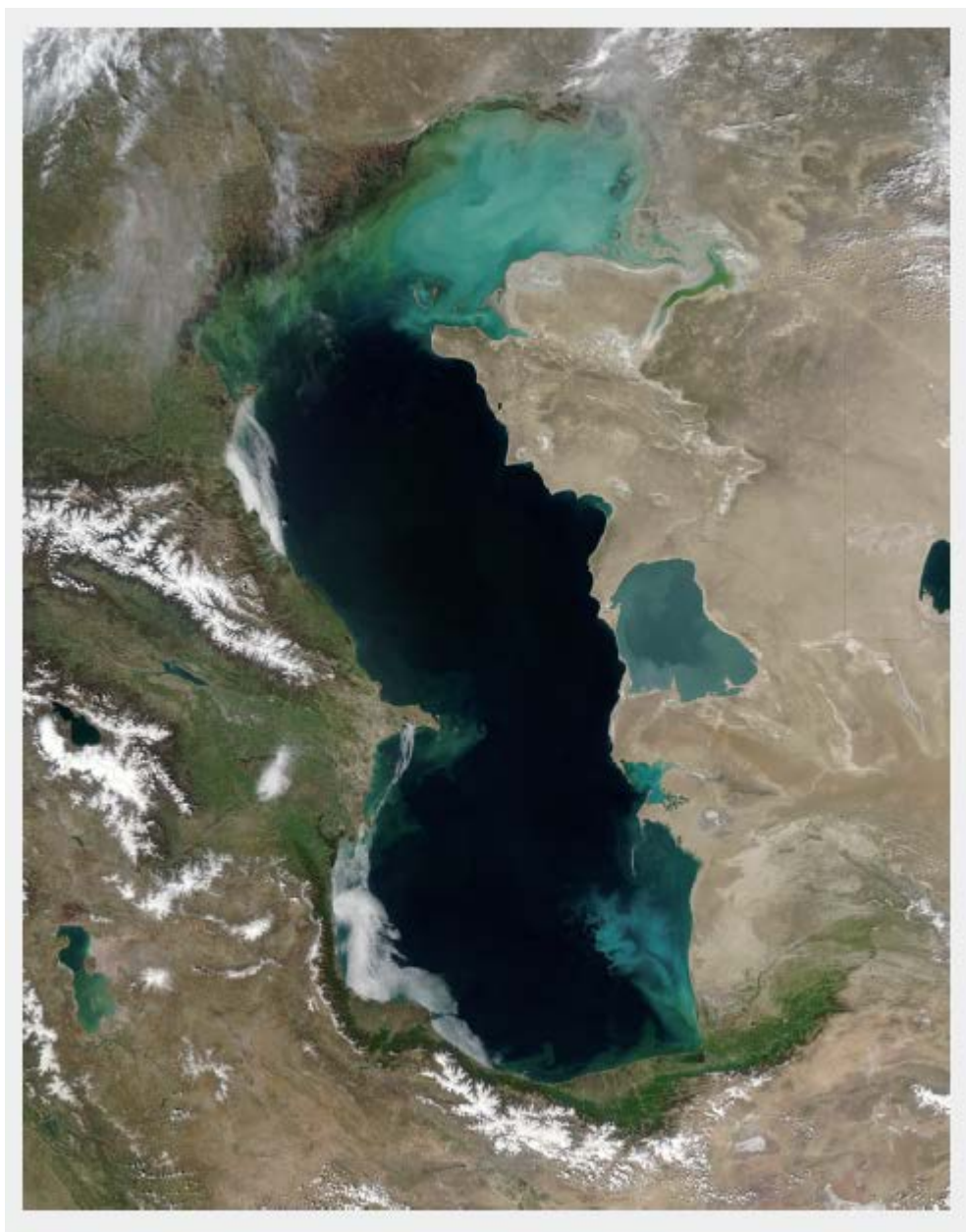
The Caspian Sea

Overview of the system

The Caspian Sea is the largest saline inland sea or lake in the world, it contains about 40% of all inland lake waters (Messenger et al., 2016) (**Figure 3.30**). This brackish water body, with salinity up to 14 g/l (Mamaev, 2002), is a home to 1,814 species and subspecies (Dumont, Mamaev and Zaitsev, 1999; Kasymov, 1987; Kazantcheev, 1981). Endemism at the species level is very high, especially among molluscs and fish. There are five sturgeon species that are endemic or shared only with the Black Sea and constitute 85 % of the standing stock of the world's sturgeon population (Dumont et al., 1999; Mamaev, 2002). The only aquatic mammal is the endemic Caspian seal (*Pusa caspica*) (Mamaev, 2002), assessed as Endangered by the IUCN (Goodman & Dmitrieva, 2016). The Caspian Sea lies on migration

9942 routes of many birds and offers refuge for a number of rare and endangered bird species (Mamaev,
9943 2002).

9944



9945

9946 **Figure 3.30: The Caspian Sea (NASA, 2004)**

9947

9948 Attribution of biodiversity trends to direct drivers

9949 Changes in the level of the Caspian Sea play a significant role for ecosystems, but their causes are
9950 uncertain. They may be caused partly by climate change and decrease of inflow after the construction
9951 of dams on the Volga River (Barannik et al., 2004; IPCC, 2014; Dobrovolskii and Zalogin, 1982; Mamaev,
9952 2002). Since 1995 the level of the Caspian Sea has not changed significantly, but it is impossible to
9953 predict the scale and direction of future fluctuations (Pekel et al., 2016).

9954 The Caspian Sea is threatened by pollution from untreated wastewater from industry and agriculture
9955 along the Volga River (an estimated 80% of the total load) (Glantz & Zonn, 1997) offshore oil and gas

production, processing, extraction and transportation, and shipping. Industrial pollution impacts biological processes including the growth of commercially important fish (Dumont et al., 1999; Mamaev, 2002).

The Lenin Canal between the Don and Volga Rivers, which opened the Caspian to maritime navigation in 1954, led to invasions by Mediterranean biota such as small crustaceans, marine molluscs (e.g. *Mytilaster Zineatus*) and comb-jelly (*Mnemiopsis lediyi*), which drove some endemic species (e.g. the bivalve *Dreissena caspia* or one of the main fish resources *Clupeonella*) to almost total extinction (Dumont et al., 1999; Rintelen & Van Damme, 2011; Zoï, 2012).

Fishing has significantly dropped during the 1990s, and slowly grew thereafter (Makoedov et al., 2007; **Figure 3.31**). During the 1990s, illegal fishing vastly increased and negatively impacted mostly sturgeon and salmon. A special moratorium on sturgeon fishing was signed by five Caspian countries in 2013. All Caspian sturgeon species are protected under CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora), but the Convention is not in force in Turkmenistan. A quota system, introduced together with a temporary ban on pelagic fishing, does not appear to have been effective in reviving the dwindling sturgeon population (Mamaev, 2002).

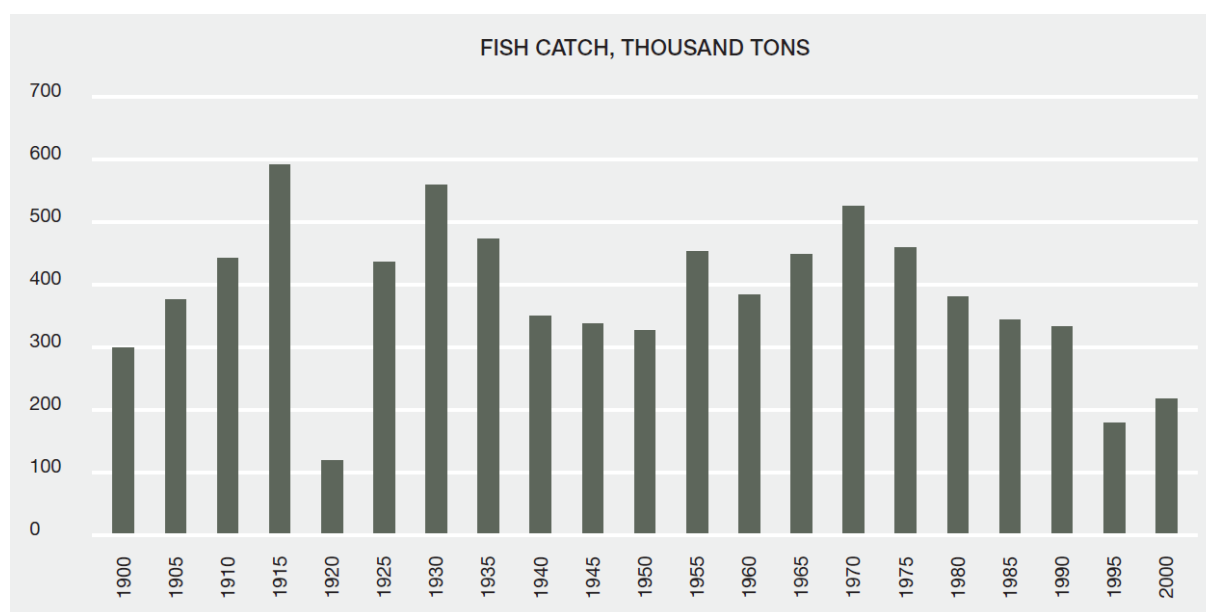


Figure 3.31: Total fishing catch in the Caspian Basin (Makoedov et al., 2007)

The population of the Caspian seal (*Pusa caspica*, a globally endangered species) has declined by 70% in the last twenty years. This is primarily due to unsustainable hunting, trapping as by-catch of the illegal sturgeon fishery, and loss of prey-base due to fishing and invasive species (Goodman & Dmitrieva, 2016; Harkonen et al., 2012). A canine distemper epidemic starting in April 2000 also contributed to the seal decline (Mamaev, 2002). Limitations on hunting were introduced in the 1940s but illegal killing of seals is still common (CEP, 2007; Mamaev, 2002).

Saline lakes

Overview of the system

In Western and Central Europe saline and brackish lakes can be found predominantly in the Mediterranean region (Čížková et al., 2013). To the east, saline water bodies are found in many terminal basins in a wide territorial belt with semiarid or arid climate including Turkey, the Caucasus, Central Asia and southern Siberia (Comin and Alonso, 1988; EEA, 2002; Kazanci, Girgin and Dügel, 2004;

9986 Kotova, Kayukova and Kotov, 2016; Kulagin, Markov and Tishkov, 1990; Montes and Martino, 1987;
 9987 Orlov. et al., 2011; Örmeci and Ekercin, 2005; Republic of Turkey, 2014; Stenger-Kovács et al., 2014;
 9988 Williams, 1981; Zektser, 2000).

9989 The biodiversity of saline and brackish lakes is variable and depends strongly, among other factors, on
 9990 salinity (Balushkina et al., 2008; Boros, Ecsedi and Oláh, 2017; Brucet et al., 2012; Ventosa and Arahall,
 9991 2009). It can be quite high in large and moderately saline lakes, for example Lake Issyk-Kul (Kulagin et
 9992 al. 1990; Savvaitova and Petr, 1999). Generally, however, increased salinity leads to a decrease in
 9993 biodiversity (Kipriyanova, Yermolaeva, Bezmaternykh, Dvurechenskaya, & Mitrofanova, 2007). In
 9994 hypersaline lakes like the Dead Sea in Israel or Lake Elton in Russia, only some algae (*Dunaliella salina*),
 9995 halophilic bacteria and fungi can be found (Nissenbaum, 1975). At the same time, many hypersaline
 9996 lakes harbour high and unique bacterial diversity that has high scientific, ecological and
 9997 biotechnological values (Oren, 2006).

9998 Saline and brackish lakes in Europe and Central Asia are crucially important for birds during seasonal
 9999 migrations and wintering. Many of them are located along transcontinental migration routes, as for
 10000 example, the Torey lakes in the Daurian steppe in Russia. Some are crucial stops along the Australian-
 10001 Asian migration route, providing temporary habitats for rare species such as 70% of the world
 10002 population of the threatened white-headed duck (*Oxyura leucocephala*), which overwinters at Lake
 10003 Burdur, Turkey, which is a designated Ramsar site (Ramsar, 1998).



10004
 10005 **Figure 3.32: Lake Chany. An example of a large saline lake with fluctuating water level, salinity and**
 10006 **biodiversity (Landsat-8, 2016).**

10007
 10008 Attribution of biodiversity trends to direct drivers

10009 There are no comprehensive assessments of changes in biodiversity in saline and brackish lakes in
 10010 Europe and Central Asia. Many saline lakes in the region experience large fluctuations in water level
 10011 and salinity, with corresponding biodiversity and ecosystems shifts (Namsaraev et al., 2008) (**Figure**
 10012 **3.32**).

10013 Fishery volume exceeds sustainable use and fish resources dwindle in the largest saline and brackish
 10014 lakes in Central Asia (Karimov et al., 2009; Thorpe et al., 2011a; Zoï, 2012), however rehabilitation
 10015 measures for fish resources (stocking of lakes with fish larvae, protection of spawning areas, etc.)
 10016 usually are not conducted (Karimov, 2011).

10017 Water withdrawal for irrigation from tributaries led to the decline of many saline lakes' area and
 10018 volume, rise in salinity and destruction of fish spawning areas and species' migration routes (Bai,
 10019 Broersma, Thompson, & Ross, 2004; Karimov et al., 2009; *Turkmenistan Fifth National Report*, 2015).
 10020 Another factor that contributes to decline of water level in saline lakes is climate change. This process
 10021 is especially strong in the arid zones of Europe and Central Asia (IPCC, 2014b). It affects salinity level
 10022 and, as a result, leads to decline in biodiversity and threatens the total extinction of the majority of
 10023 species (Bai et al., 2004).

10024 It is projected that many lakes in the Mediterranean climate zone will be markedly affected by
 10025 aridification and water abstraction, with related changes in water level, salinity, biodiversity and the
 10026 ecology of lakes and reservoirs (Jeppesen et al., 2015). Artificial saline lakes are also created in natural
 10027 depressions of Central Asia by storing collector-drainage water after irrigation (Stone, 2008; Thorpe et
 10028 al., 2011; Yakubov, 2011). They are extremely polluted by agricultural chemicals, initially with low
 10029 biodiversity limited to some algae and bacteria (Glazovsky, 1990; Orlov et al., 2011). However, there
 10030 are projections that these man-made ecosystems can be important for biodiversity conservation,
 10031 fisheries, migration birds and recreation (Karimov and Kamilov, 2014; Sadikov et al., 2015; Thorpe et
 10032 al., 2011b).

10033 As large saline and brackish lakes have a long history of isolation from each other, they have been
 10034 refugees for rare and endemic species. These species are more strongly affected than others by non-
 10035 native invasive species, which reach saline lakes sometimes accidentally, sometimes through
 10036 introduction by humans to improve fisheries, like in Issyk-Kul lake (Kulagin et al., 1990; Thorpe et al.,
 10037 2011).

10038

10039 *3.3.3.3 Implementation of the Ramsar Convention by the countries of Europe and Central Asia*

10040 All countries in Europe and Central Asia are Contracting Parties to the Ramsar Convention, except San
 10041 Marino.

10042 According to a national reports review undertaken by the Secretariat of the Convention (Ramsar,
 10043 2015a, 2015b), Ramsar wetlands in the region face increasing pressures from rapid urbanization and
 10044 land-use changes for tourism, infrastructure development (transport and energy) and non-sustainable
 10045 exploitation of natural resources (e.g. water, gravel, peat, oil, gas). Ongoing climate change increases
 10046 environmental risk and the frequency of natural hazards such as floods, droughts, storms and
 10047 landslides, especially in Central Asian countries. The regulating services that wetlands can provide are
 10048 only rarely taken into account. Wetlands in Eastern Europe and Central Asia are under increasing
 10049 pressure especially from conversion due to population increase (Central Asia) and development
 10050 projects (Eastern Europe), overuse of wetland resources, expansion of human habitats and
 10051 infrastructure, agricultural, recreational and development activities, and pollution. In Central Asia
 10052 there are difficulties with water availability for wetlands, and there is competition for water within and

between countries. There are cases in Central Asia of wetland loss due to the natural disasters – such as droughts and landslides.

An assessment of Ramsar Convention implementation was undertaken (**Table 3.2**) considering progress towards the four main goals of the Convention: 1 - wise use of wetlands, 2 - creating a network of wetlands of international importance (Ramsar Sites), 3 - international cooperation, and 4 - institutional capacity and effectiveness (**Table 3.3**).

Table 3.2: Implementation of the Ramsar Convention in Europe and Central Asia: reporting statistics

Subregion	Number of countries reporting to the Convention	Total sites number	New sites last reporting period	Sites under threat or with changed ecological character	Official reporting on Ramsar site ecological character change
Western Europe	18 of 24	805	46	62 (8% of all sites)	17 (27% of sites changed or under threat)
Central Europe	13 of 18	174	11	27 (15%)	15 (55%)
Eastern Europe	5 of 7	110	6	17 (15%)	1 (6%)
Central Asia	1 of 5	21	1	1 (n/a)	1 (n/a)

The number of Ramsar sites is highest in Western Europe, while these sites cover smaller areas than in other subregions. Western Europe is also more active in designating new sites. Fewer sites in Western Europe are under threat than elsewhere. Nevertheless, those that are under threat are reported by NGOs or local communities, and seldom via official channels to the Ramsar Secretariat. Eastern and Central Europe has a higher portion of endangered sites, but more often reported via official channels. In Central Europe 55 % of sites with changing ecological character were reported via official channels, while in Eastern Europe it was only in 5 % of cases. Central Asia cannot be assessed due to a lack of information except for Kazakhstan, which also reports its endangered Ramsar site officially and was visited by a Ramsar mission.

As part of the wise use of wetlands, countries are reporting on successful wetland restoration projects and work related to water policies and river basin management including the European Union Water Framework Directive (**Table 3.3**). Within goal 2, countries report on the development of management plans for Ramsar Sites and the implementation of their provisions; wetland monitoring and inventory activities; and the preparation and designation of new Ramsar Sites and synergies with the European Union Natura 2000 network of protected areas. Goal 3 is on international cooperation. The steps to meet goal 4 mostly are communication, education and outreach activities, including World Wetlands Day; and the development of national policies for conservation, biodiversity and wetlands including national biodiversity strategies and action plans.

The steps to meet goal 4 mostly are communication, education and outreach activities, including World Wetlands Day; and the development of national policies for conservation, biodiversity and wetlands including national biodiversity strategies and action plans.

Table 3.3: Implementation of the Ramsar Convention in Europe and Central Asia: progress toward goals. Yes = goal achieved; In part = goal partially achieved; No = Goal not achieved.

Subregion	Goal 1: Wise use of wetlands	Goal 2: Network of Wetlands of the International Importance (Ramsar Sites)	Goal 3: International cooperation	Goal 4: Institutional capacity and effectiveness
Western Europe	Yes	No	Yes	No
Central Europe	Yes	In part	Yes	No
Eastern Europe	In part	Yes	Yes	In part
Central Asia	In part	In part	In part	In part

The greatest difficulties reported are limited administrative capacity resulting from limited human and financial resources; slow administrative processes to put effective policies in place; and insufficient coordination between wetland, water, and river basin management authorities. Progressing with wetland ecosystem conservation on the ground is difficult, because it needs to be based on time-consuming inter-sectoral stakeholder consultations. Agricultural, urban and land-owner interests hinder the implementation of Ramsar objectives. The lack of political interest, economic incentives in the absence of wetland valuations, and sufficient wetland inventories are reported by Europe and Central Asian countries.

3.3.4 Marine Systems

The marine environment of Europe and Central Asia, which includes open ocean areas and semi-enclosed seas encompassing several marine ecoregions, (Spalding et al., 2007) is very diverse at genetic, community, ecosystem and seascape levels. This environment has been significantly impacted by human activities for millennia but marine research in some parts of the region is well established, resulting in some of the best studied marine ecosystems in the world. Still about 53% of the benthic shallow habitats in Western and Central Europe were found to be Data Deficient in recent habitat assessments (Gubbay et al., 2016). Of the assessed benthic habitats, about 38% were classified as threatened in the categories Critically Endangered, Endangered and Vulnerable. In the European Union, for marine species and habitats of conservation interest only 9% of habitats and 7% of marine species were considered to be in “favourable conservation status”, while 66% of habitats and 27% of species assessments were in “unfavourable conservation status”.

For the purpose of the current assessment the marine environment was divided into the different ocean basins and semi-enclosed seas of the region including the North East Atlantic Ocean, with different sections for the Baltic, Mediterranean and Black Seas, the Eurasian Arctic Ocean and the North West Pacific Ocean, focusing on the exclusive economic zones of countries of Europe and Central Asia, and of the relevant regional agreements.

3.3.4.1 North East Atlantic Ocean

Overview of the system

The European part of the Atlantic Ocean (*sensu lato*, i.e. North Sea, Irish Sea, English Channel, Iberian coast, and the Macaronesian Island coasts except for Cape Verde) encompasses large latitudinal

gradients, several biogeographic provinces from Arctic to warm temperate systems realms (Spalding et al., 2007), and a diversity of ecosystems and habitats, including complex structural habitats like seagrass meadows, kelp forests and biogenic reefs, providing a diverse set of nature’s contributions to people (Prather et al., 2013; Smale, Burrows, Moore, O’Connor, & Hawkins, 2013; Worm et al., 2006). Despite knowledge gaps, several trends are well established thanks to the sustained observation of marine biota particularly in the Celtic Sea, English Channel, North Sea and Bay of Biscay (e.g. Barceló et al. (2016); Beaugrand, Gregory; Luczak, Christophe; Edwards (2009); Daan et al. (2005); EEA (2015e); Morten Frederiksen et al. (2013); Mieszkowska et al. (2014); OSPAR (2010, 2017)).

Past and present trends

Changes in distribution and species abundance are the most well documented trends, across diverse taxonomic groups, as illustrated in over 670 observational data points extracted from Poloczanska et al. (2013) and summarized in **Figure 3.33**.



Figure 3.33: Number of species for which changes in distribution, abundance or functioning (including demography, phenology, assemblages) have been documented since the 1950s (time series over more than 23 years), per functional groups. Data are shown separately for each taxonomic (functional) group. The dotted line provides the percentage of species with no change

observed over all the trends considered. Data for the North East Atlantic extracted from the Table S1 in Poloczanska et al. (2013).

Shifts in range, in particular northward expansion of more than 140 km per decade on average across taxa (Poloczanska et al. 2013), have been shown (Figure 3.34). This is exemplified by the subtropicalization of European pelagic fish communities (Montero-Serra, Edwards, & Genner, 2015), by movements of calanoid copepods towards the north at rates of up to 23km per year between 1958 and 2009 (Beaugrand, Luczak, & Edwards, 2009) and by shifts of the centre of the distribution for about 60% of 65 marine invertebrates studied in the North Sea (Hiddink, Burrows, & García Molinos, 2015). Range shifts occur not only in latitude, but also along depth gradients (e.g. Dulvy et al. (2008) for fishes; Hiddink et al. (2015) for marine invertebrates). Range shift is, however, not fast enough to keep pace with climate change for many species (Hiddink et al., 2015), so other effects of climate change, such as phenological changes, are also observed. Also, as shown Figure 3.34, the rate of change varies across taxa: northward expansion of benthic algae display an average range shift of 42km per decade which is an order of magnitude slower than that documented for fishes (Perry, Low, Ellis, & Reynolds, 2005; Poloczanska et al., 2013). Importantly, although documented in a few taxa only, such range shifts can provoke the loss of particular genetic clades (e.g. in the macroalga *Fucus vesiculosus*, (Nicastro et al., 2013) and impoverished genetic diversity at species level, with putative ecological and economic impacts (Parmesan, 2006).

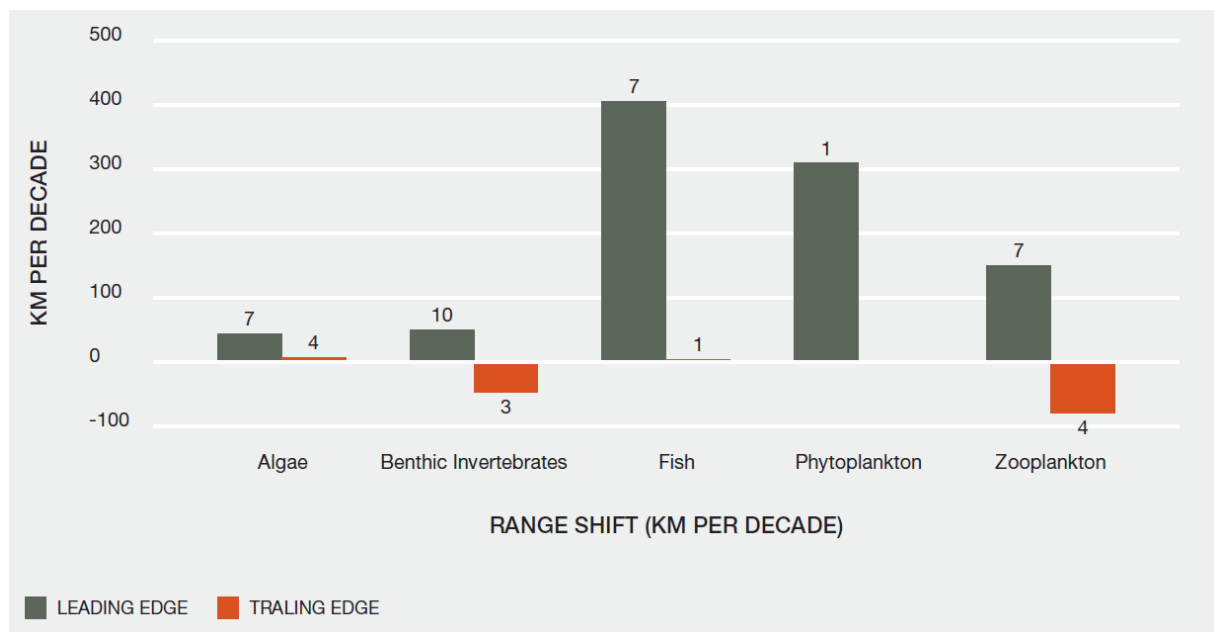


Figure 3.34: Range shift (northward expansion – leading edge; southern contraction - trailing edge) of taxonomic/functional groups in the NE Atlantic. Numbers above bars indicate the number of taxa for which data are available. Data extracted from Table S6 by Poloczanska et al. 2013.

In the 20th century almost all fish stocks of the North Atlantic have been depleted in abundance, with consequential impacts on stock biomass, size distribution, and diversity (reviewed in Rice et al. (2016)). Many fish stocks are currently overfished. However, in the 21st century, fishing has been reduced in most parts of the North East Atlantic shelves, and there is evidence of recovery in most of these areas, albeit at different rates for different species (Rice et al., 2016). A combination of range shifts and fishing is responsible for genetic changes, such as declines in genetic diversity in fishes, as observed in the North Sea cod (Hutchinson, van Oosterhout, Rogers, & Carvalho, 2003). Populations of most marine bird species have been declining since 2002 (Frederiksen, 2010), with the exceptions only of the northern gannet (*Morus bassanus*) and great skua (*Stercorarius skua*), both likely benefiting from

10167 increasing availability of fishery discards, and, for the gannet, from recovery from past persecution
 10168 (Frederiksen et al. 2009). These changes in abundance lead to local population and species decline,
 10169 which affect a variety of fish and bird taxa, as detailed above, but also primary producers such as
 10170 phytoplankton, with important consequences for trophic networks (McQuatters-Gollop, Raitsos,
 10171 Edwards, & Attrill, 2007), and marine invertebrates including crustaceans, annelids, and molluscs
 10172 (OSPAR, 2008; Wiens, 2016).

10173 Another clearly documented change is biotic homogenization, due to species range shifts (e.g. for
 10174 fishes assemblages, Magurran et al., 2015) combined with the introduction of alien species. An
 10175 estimated 237 species have been introduced into the North East Atlantic (Galil et al., 2014), having
 10176 steadily increased by about 173 species from 1970 to 2013. Many of these alien species were
 10177 introduced deliberately (e.g. the Asian oyster (*Magallana gigas*), with which many other “hitch-hiking”
 10178 species have been accidentally introduced. This is a consistent past and current trend over a large
 10179 range of taxa (Seebens et al., 2017).

10180 Changes in distribution and abundance also impact habitat-structuring species, such as seagrass and
 10181 kelp forests, which are both natural carbon sinks and thus may contribute to carbon sequestration, or
 10182 biogenic reefs, for example *Sabellaria spinulosa* or flat oyster reefs, both of which are included on the
 10183 OSPAR list of threatened or declining habitats; (OSPAR, 2008)). Disease outbreaks have also been
 10184 reported in cold-water corals, like the seafan *Eunicella verrucosa* (Hall-Spencer, Pike, & Munn, 2007),
 10185 a structuring perennial species listed on the IUCN Red List’ of threatened species. The decline in extent
 10186 and abundance of these diverse structuring species modifies ecosystem functioning as well as the
 10187 contributions that they provide to people. For instance, a shift from kelp canopies to turf-forming
 10188 seaweeds has a global impact on community structure and function (Smale et al., 2013) as well as on
 10189 fisheries (Bertocci, Araújo, Oliveira, & Sousa-Pinto, 2015). These habitat-forming species are
 10190 insufficiently monitored (e.g. for kelps see (Araújo et al., 2016)), but current trends have already
 10191 documented declines, as exemplified by *Cymodocea* meadows, with estimated declines of between
 10192 15% and 80% in extent along the Iberian Peninsula coasts. Changes in ecosystem functioning (e.g. food
 10193 web and trophic network) have also been well-documented in some areas, e.g. in pelagic systems of
 10194 the North Sea (e.g. copepods-fishes (Beaugrand, 2004; Kirby and Beaugrand 2009)).

10195 Phenological changes (e.g. earlier timing of recruitment) are an important component of these changes
 10196 in ecosystem functioning. They can affect populations through diverse mechanisms and with large
 10197 impacts such as mismatches with food resource availability and increased mortality because of non-
 10198 favourable environmental conditions (Thackeray et al., 2010 and references therein). They have been
 10199 established with confidence for several taxonomic groups (Edwards & Richardson, 2004; Kirby &
 10200 Beaugrand, 2009; Poloczanska et al., 2013; Thackeray et al., 2010). For some taxa such as marine
 10201 invertebrates (Thackeray et al. 2010), rates of advance in seasonal timing was shown to increase over
 10202 recent decades.

10203 Changes in patterns and processes, as detailed above, are indicative of a decline in biodiversity status,
 10204 now and in the past, at species, community and ecosystem levels.

10205 Although biodiversity decline and changes in ecosystem functioning are widespread, a few trends are
 10206 indicative of partial recovery when compared with past-trends. With the exception of Atlantic cod,
 10207 there are signs of improvement in fish stocks and biomass, especially compared with other Western
 10208 European waters such as the Mediterranean Sea (Fernandes et al., 2017a). The number of assessed
 10209 stocks that are above their maximum sustainable yield has dropped from 94% in 2007 to 41% in 2014
 10210 in European Union Atlantic and Baltic waters, which has been explained by an overall decrease in the
 10211 level of fishing pressure (Daan et al., 2005; EEA, 2015c). Moreover, with 3,203 marine protected areas
 10212 extending over 171,174 km², 5,9% of the surface of the North East Atlantic benefits from protection.

There are, nevertheless, discrepancies between sea areas (e.g. 14.7% Greater North Sea vs. 5.9% Bay of Biscay and Iberian coasts) and distance from the shore (52.1% of 0-1 nautical miles zone vs. 2.3% beyond 12 Nautical miles). The increase in network coverage is a positive current trend, but still below the Aichi Biodiversity Target 11 of 10 % of marine habitats under protection (EEA, 2015a; OSPAR 2017) over the whole North East Atlantic area. In addition, only 10% of marine habitats that have been assessed have a favourable conservation status (EEA, 2015b), with contrasted features across areas. For instance, while the Macaronesian region reported 33% of favourable habitat conservation status, the other areas of the North East Atlantic reported 71% of unfavourable-bad assessments (EEA, 2015a). Finally, no fauna extinction has been documented so far, maybe due to major knowledge gaps for important taxonomic groups like marine invertebrates (McCauley et al., 2015).

Attribution of biodiversity trends to direct drivers

The primary pressures responsible for past regime shifts in shelf ecosystems are overfishing, pollution and climate driven changes including Arctic ice melting and ocean warming. In terms of the importance of these direct drivers for past trends, they are graded as high impact (**Table 3.5**).

Overall, several studies point with a high confidence to climate change, including ocean acidification as the main emerging driver in the North East Atlantic (Barceló et al., 2016; Beaugrand, McQuatters-Gollop, Edwards, & Goberville, 2013; Birchenough et al., 2015; Fossheim et al., 2015a; Hiddink & ter Hofstede, 2008; Montero-Serra et al., 2015; Poloczanska et al., 2016)). Eighty-six percent of the changes documented by Poloczanska et al. (2013) are consistent with expectations based on climate change effects, although most often (82% of the cases examined), other drivers are acting simultaneously. These include natural resource exploitation with direct (e.g. overfishing) or indirect (e.g. trawling and demersal fishing activities on benthos) effects, land and water use (eutrophication, pollution, including plastics and microplastics), habitat changes (marine urbanization) and invasive species. There are also substantial cumulative impacts of this diverse set of drivers (Halpern et al., 2015).

Between the past and current periods, the importance of the effect of climate change has not decreased. Conversely, the importance of changes due to natural resource exploitation has likely been decreasing (i.e. graded as moderate for current trends in **Table 3.5**. For example, in benthic communities bottom trawling is one of the main pressures (Rice et al., 2016), but recoveries have been observed following cessation of this activity (Kaiser et al., 2006). Similarly, overfishing remains high (50% of fish stocks in the North East Atlantic) but positive trends are now observed. For example, fishing effort decreased by 25% from 2000 to 2006 in the Greater North Sea (EEA, 2015e; OSPAR, 2010). The same can be said for pollution: coastal benthic communities have been strongly affected by nutrients and pollutants runoff and climate change (Rice et al., 2016) but nutrient inputs are now reduced, even if still cause for concern (OSPAR 2010, 2017). However other categories of pollutants (e.g. xenochemicals, microplastics) might have substantial effect, but have not yet been assessed (see chapter 4). Conversely, besides climate change, the impact of man-made structures on seabed and coastal habitats has been increasing. These include structures associated with urbanization of coastal areas, coastal land defences and a growing number of offshore structures (EEA, 2015e), and associated ecosystems and species. The importance of invasive alien species has been increasing in a recent past, with 44 high-impact species (Castro, Fileman, & Hall-Spencer, 2017))(**Box 3.3; Table 3.5**).

3.3.4.2 Baltic Sea

Overview of the system

The Baltic Sea is a shallow brackish waterbody characterized by strong seasonal variability and decreasing gradients of salinity and temperature from south-west to north-east. It is an almost non-tidal sea that spans from the temperate, highly populated and industrialized south with intensive agriculture, to the boreal and rural north. It is a young, low diversity ecosystem inhabited by species of both marine and freshwater origin, migratory species and glacial relicts (Segerstråle, 1957). Despite being well-studied compared with other aquatic systems (Mark John Costello et al., 2010), several ecosystem parts are still under-investigated (Ojaveer et al., 2010).

Past-and current trends

International coordination of research in the Baltic Sea has been ongoing since the beginning of the 20th century, but long-term datasets are only available from the 1950s for benthos, plankton and fishes (Ojaveer et al. 2010). Due to the absence of long-term monitoring for many other taxa, several parts of the ecosystem are under-investigated and thus under-evaluated. Several biodiversity assessment tools have been created for the assessment of biodiversity, but most of them have only been applied in marginal areas of the Baltic Sea (Andersen et al., 2014; Aunins & Martin, 2014). The overall health of the Baltic Sea is currently in a bad state, with significant decline in the status of biodiversity in large areas (BalticSTERN, 2013; HELCOM, 2009, 2010), as can be seen in the indicators in **Figure 3.35**. Only the Bothnian Sea and some coastal areas in the Bothnian Bay have an acceptable status in terms of different elements of biodiversity. The grey seal population is in good status in the whole Baltic Sea (**Figure 3.35**).

Regime shifts and fish trends

In general, fish communities of the Baltic Sea are very unstable due to substantial decline or lack of large predatory fish in the system. Several species are of concern in achieving the Baltic Sea Action Plan community level targets (HELCOM, 2009). Several currently threatened or declining fish species are negatively influenced by eutrophication and pollution (Fernandes et al., 2017b; HELCOM, 2009). Coastal fish species are declining in shallower areas, mainly due to increasing temperature (Snickars, Weigel, & Bonsdorff, 2015). Latest assessments indicate a good biodiversity status for about half of the assessed coastal area (HELCOM, 2017f). In addition, reduced salinity reduces the food base for benthic feeding fish in deeper areas (Snickars et al., 2015).

The open areas of the Baltic Sea have undergone several regime shifts in the 20th century (Österblom et al., 2007). Such changes are primarily caused by the combination of weakened top-down pressure and increased primary production (Möllmann, Müller-Karulis, Diekmann, Flinkman, & Gårdmark, 2007). These ecosystem shifts are well observed in cod populations. The current decline of cod populations can be attributed to the large scale fishing industry and results in a significant increase in sprat populations (HELCOM, 2010), changes in zooplankton communities (Rönkkönen, Ojaveer, Raid, & Viitasalo, 2004) and thus reduced growth of the Baltic herring. In addition, changing climate conditions and lack of saline water inflows have created environmental conditions unsuitable for marine fishes (e.g. cod). Although, in some areas, signs of recovery have been observed for cod populations (Cardinale & Svedäng, 2011), recovery to safe biological limits has not yet been reached (HELCOM, 2010). Sturgeon, a very important commercial species for centuries, is now a red-listed species. A reintroduction program has being developed with eggs from the St. John river in Canada (Kolman, Kapusta, & Duda, 2011). In the open sea, a good status in terms of fish biodiversity has not been achieved in any assessment area (HELCOM, 2017f).

Marine mammal trends

In the early 1900s strong hunting pressure followed by toxic pollution substantially decreased all populations of marine mammals in the Baltic Sea resulting in a “Critically Endangered status” for the Baltic Sea harbour porpoise (Hammond et al., 2008; HELCOM, 2009, 2013) and an order of magnitude decrease in the number of seals (Harding & Härkönen, 1999). Although, the conservation status of marine mammals in the Baltic Sea was considered as unfavourable for most of the species assessed (EEA, 2015f), there are some signs of an increase of top predators, mostly seals and predatory birds, during recent decades (HELCOM, 2013, 2017d). Population size of grey seals is considered as favourable in several Baltic Sea areas (**Figure 3.35**) and this recovery is interfering with fishing activity and an unknown number of seals are drowning in fishing gear every year (Vanhatalo, Vetemaa, Herrero, Aho, & Tiilikainen, 2014). But the assessment of their nutritional and reproductive status is still not good (**Figure 3.35**). In addition several migratory bat species populations are negatively impacted by wind turbine development (Voigt, Popa-Lisseanu, Niermann, & Kramer-Schadt, 2012). An expert evaluation of endangered species in the Baltic shows that a number of species are still at risk of extinction (HELCOM, 2013).

Marine bird trends

No clear trends are evident for marine bird populations, but populations are not considered stable in the Baltic Sea. Substantial long-term declines can be attributed to anthropogenic factors, through lower reproductive success. However, some bird species (e.g., cormorants) may benefit from certain anthropogenic activities (HELCOM, 2009). A cascading effect from overfishing, that targets predator fish, has also improved the food base for some birds, as more prey becomes available to them (e.g. auks) (HELCOM, 2009). In addition, climate change has impacted the range and population size of migrating species through changes in breeding areas (HELCOM, 2009, 2017b). In recent decades, over half of wintering water bird species have declined significantly and the reasons for their decline are not currently understood (BalticSTERN, 2013; HELCOM, 2017c).

Plankton trends

The species dominance and biodiversity of phytoplankton have significantly changed over the past 100 years (Feistel, Nausch, & Wasmund, 2008; Hällfors et al., 2013; HELCOM, 2009; Wasmund, Göbel, & Bodungen, 2008). In recent decades, however, there have been few clear trends. Long-term increases in cyanobacteria blooms present a challenge to achieving good Baltic Sea Action Plan environmental status (HELCOM, 2009). During the past few decades, the dominant zooplankton taxa have undergone considerable changes, driven by natural shifts and human impacts. These changes are causing a cascading effect in the food web, affecting upper trophic levels (HELCOM, 2009).

Benthos and habitat forming species trends

Currently, macrobenthic communities are severely disturbed and degraded in several Baltic Sea areas (HELCOM, 2009; Norkko, Laakkonen, & Laine, 2007) and long-term patterns indicate a “shifting baseline” (HELCOM, 2009). From 1994 to 2005 marine invertebrates in the Kattegat area decreased from 230 to 180 species and this decline continued until 2011, when some taxonomic groups were found to have only one third of the species recorded in 1994 (EEA, 2015). In general, the dominance of perennial habitat-forming macrophytes, such as bladder wrack, eelgrass and charophytes, is gradually decreasing and currently being replaced by phytoplankton and fast growing annual phytobenthic species (Dahlgren & Kautsky, 2004; HELCOM, 2009, 2010; Korpinen & Jormalainen, 2008). However, some range expansion in several important macroalgal species has been observed in the area of the Northern Baltic Proper (HELCOM, 2009, 2013). For example, bladder wrack has increased its range in depth (HELCOM, 2009) and its status is considered of Least Concern in the most recent assessment (HELCOM, 2013). Eelgrass populations have undergone several restoration

10348 attempts after being almost destroyed by diseases in the 1930s. Long-term trend indicates significant
 10349 fluctuations in eelgrass distribution in the Baltic Sea, with higher instability in sheltered areas (Morten
 10350 Frederiksen, Krause-Jensen, Holmer, & Laursen, 2004). In addition, mussel beds have undergone
 10351 significant transformation and further decline is expected due to the range expansion of invasive
 10352 species preying on mussels (Westerbom et al., 2002; HELCOM, 2009; Ojaveer et al., 2016). In open sea
 10353 areas soft bottom invertebrate communities are in good condition in a large part of the Baltic Sea
 10354 (HELCOM, 2017f, 2017g).

10355 *Invasive species trends*

10356 The number of non-indigenous species in the Baltic Sea is growing (HELCOM, 2009, 2017f, 2017h).
 10357 Over half of those recorded have become established in at least one of the Baltic Sea countries
 10358 (Ojaveer et al., 2016).

10359

10360 Attribution of biodiversity trends to direct drivers

10361 Eutrophication, overfishing, and a significant decline in the abundances of marine mammal
 10362 populations were the most important drivers of change in the Baltic Sea in the 20th century (Ojaveer
 10363 et al., 2010). Currently major environmental problems include eutrophication caused by increasing
 10364 river runoff, overfishing, hazardous substances, risk of chemical or oil spills, invasive species, habitat
 10365 loss due to anthropogenic factors, and climate change induced changes, i.e. in temperature and salinity
 10366 (BalticSTERN, 2013; Mark John Costello et al., 2010) (**Box 3.3, Table 3.5**). Assessments of the status of
 10367 widespread pressures like marine litter, including microplastics and underwater sound are currently
 10368 unavailable, but need to be assessed (HELCOM, 2017f). Most areas are subject to multiple stressors
 10369 (Andersen, Halpern, Korpinen, Murray, & Reker, 2015).

10370 *Eutrophication*

10371 All open waters and coastal areas of the Baltic Sea, with the exception of some areas in the Bothnian
 10372 Bay, are changing due to eutrophication (HELCOM, 2010). Altogether 97% of the surface area in the
 10373 Baltic Sea is eutrophic (HELCOM, 2017f). The sea floor area where hypoxia occurs has increased 10-
 10374 fold over the last 115 years (Carstensen, Andersen, Gustafsson, & Conley, 2014). In open waters, the
 10375 increase of oxygen-deficient zone areas is the main driver of change in biodiversity and benthic
 10376 community functioning (Carstensen et al., 2014; HELCOM, 2009). Areas with eutrophication-induced
 10377 coastal hypoxia are becoming more common both in deep and shallow water habitats (Conley et al.,
 10378 2011). In the northern Baltic Sea, hypoxic disturbance degrades the structure and function of seafloor
 10379 communities and sediment nutrient cycling (BalticSTERN, 2013; Villnäs, Norkko, Lukkari, Hewitt, &
 10380 Norkko, 2012). There are improvements in eutrophication status that are direct consequences of long-
 10381 term efforts to reduce nutrient inputs (Andersen et al., 2015; HELCOM, 2017f), but the overall target
 10382 of a Baltic Sea unaffected by eutrophication has not yet been met (Svendsen, Pyhälä, Gustafsson,
 10383 Sonesten, & Knuuttila, 2015).

10384 *Overfishing*

10385 Overfishing is one of the main drivers of change in the Baltic Sea ecosystem, because low diversity
 10386 systems are more prone to cascading effects caused by the decline of top predators (BalticSTERN,
 10387 2013). Technical improvements in fishing methods have increased landings since the second half of
 10388 the 20th century in the overpopulated Baltic Sea area. In addition, construction and regulations in main
 10389 watercourses have disturbed the natural reproduction of migratory fish species (BalticSTERN, 2013).
 10390 Since the collapse of the cod stock in the 1980s, landings have been reduced, but due to a shifting
 10391 regime the cod stocks have not recovered (HELCOM, 2010).

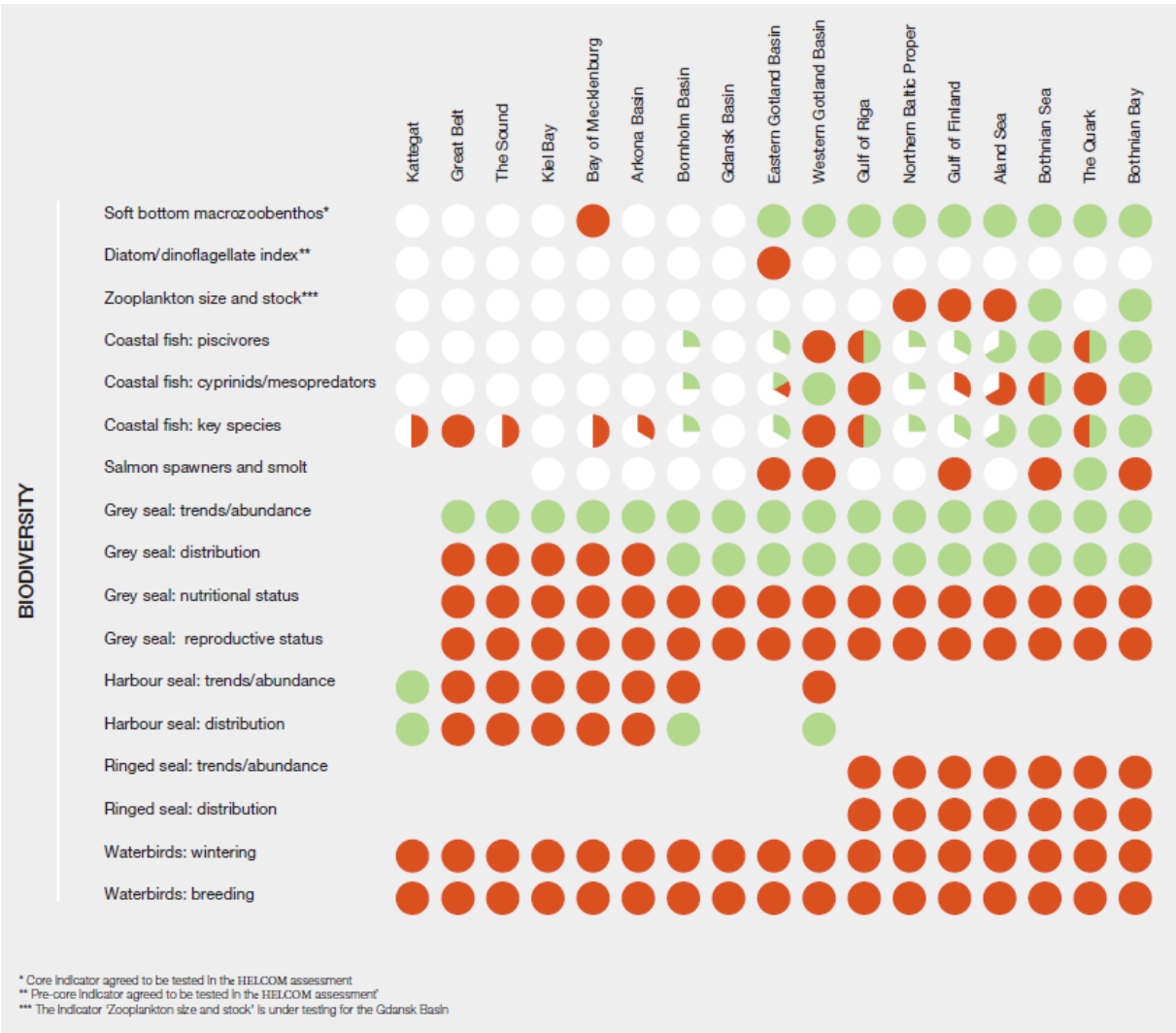


Figure 3.35: Status of biodiversity core indicators by sub-basin of the Baltic Sea. Green circles indicate good status, red circles indicate not good status, and empty circles indicate that the core indicator is applicable for the sub-basin, but has not been assessed. Absent circles indicated that the indicator is not applicable. For coastal indicators, pie charts show proportion of coastal assessment units per sub-basin in good status (green), not good status (red) and not assessed (empty). (HELCOM, 2017f)

Invasive species

Fewer non-indigenous species are recorded in the Baltic Sea than in other European Seas (Galil et al., 2014). Nevertheless, due to low native species diversity, underrepresentation of several ecosystem traits, and overall large disturbances in habitats, alien species are having severe impacts on the Baltic Sea ecosystem (BalticSTERN, 2013; Leppäkoski et al., 2002). Ecological impacts caused by the invaders vary depending on how they differ from natives in their life form and resource usage (HELCOM, 2009).

Climate change

Climate change amplifies the effect of all other drivers of change (Snickars et al., 2015). In the Baltic Sea eutrophication rates are increasing through increased nutrient fluxes from increased river runoff. Warmer temperature and an increase in extreme temperatures are making the areas better suited for the establishment of alien species. Moreover, increased riverine flows result in lower salinities with detrimental impacts on all species of marine origin.

10411 In summary, the Baltic Sea is well studied and its ecosystems and biodiversity have been very degraded
 10412 in the past. Management plans for recovery have been in place for some years, and although in general
 10413 the status of biodiversity is still considered poor, some signs of recovery have been observed.

10414

10415 *3.3.4.3 Mediterranean Sea*

10416 Overview of the system

10417 The Mediterranean Sea, covering approximately 2,500,000 km², is a remnant of the Tethys ocean, an
 10418 ancient ocean from the Mesozoic era. The sea's main hydrologic features are: i) a microtidal regime;
 10419 ii) scarce freshwater inputs compensated by inflow of Atlantic surface water; iii) highly saline (38 to
 10420 39.5‰) concentration basin with higher evaporation eastwards; iv) oligotrophy, with organic carbon
 10421 inputs 15-80 times lower in the eastern than in the western basin and extremely low concentrations
 10422 of chlorophyll-a in surface offshore waters (ca 0.05 µg l⁻¹); and v) with almost constant temperature
 10423 from about 300-500m downwards, with bottom temperatures about 12.8 - 13.5°C in the western basin
 10424 and 13.5 - 15.5°C in the Eastern basin.

10425

10426 Status and trends

10427 Despite covering only 0.82% of global oceanic surface, the Mediterranean sea is host to more than
 10428 17,000 described marine species, representing an estimated 7% of the world's marine biodiversity,
 10429 including about 25 to 30% of endemic species (Coll, Shannon, et al., 2010; Mouillot et al., 2011).
 10430 Longitudinal and latitudinal patterns distinguish a dozen biogeographic regions, from the Alboran Sea
 10431 to the Levantine Basin (Bianchi et al., 2012), and a great number of unique ecosystems (Coll et al.,
 10432 2010; Danovaro et al., 2010). The apparent eastwards decrease in biodiversity follows a gradient of
 10433 production, but its true extent is still not clear. Biodiversity is generally higher in coastal areas and on
 10434 continental shelves. Biodiversity, excepting bacteria and archaea, decreases with increasing water
 10435 depth, but to a different extent in different taxa. Danovaro et al., (2010) estimate the deep-sea
 10436 biodiversity of the Mediterranean (excluding prokaryotes) at 2,800 species, of which two thirds
 10437 remains undiscovered.

10438 In recent habitat Red List assessments carried out for 47 benthic shallow (<200m depth) habitats off
 10439 the northern shores of the Mediterranean, 60% were considered Data Deficient. Of the remaining
 10440 habitats 74%, (14 habitats) were threatened (Gubbay et al., 2016).

10441 Some fish and invertebrate populations have been decimated in recent years. Of the 519 native marine
 10442 fish species and subspecies in the Mediterranean Sea, more than 8% (43 species) were classified in
 10443 threatened categories (Critically Endangered, Endangered or Vulnerable). Of the 15 Critically
 10444 Endangered species, 14 are sharks and rays. Thirteen species are listed as Endangered, nine of them
 10445 sharks and rays (Malak et al., 2011). Cartilaginous fishes in general are declining in abundance, diversity
 10446 and range (Cavanagh & Gibson, 2007). In the red list assessment of Mediterranean Anthozoans 69
 10447 species (51%) were listed as Data Deficient (DD), and from the remaining about 25% were found to be
 10448 threatened with extinction (Critically Endangered, Endangered or Vulnerable), including two of the
 10449 endemic species (Otero et al., 2017).

10450 Mediterranean phyto- and zooplankton blooms, including jellyfish and comb jellies, are regional,
 10451 seasonal and species-specific phenomena. These blooms have likely benefited from overfishing,
 10452 eutrophication, habitat modification, aquaculture, global warming and human-mediated dispersal
 10453 (Boero, 2013). Documented increases in bloom frequency, duration, and spatial extent have negatively
 10454 impacted food web structure, as well as economy and human health (Ferrante et al., 2013) although

10455 in some cases, jellyfish can contribute to maintain water quality and prevent phytoplankton blooms
10456 exerting a top-down control of the trophic web (Pérez-Ruzafa et al., 2002).

10457 Concurrent expansion of the range of warm-water species (native, recent Atlantic thermophilic entries,
10458 tropical Erythraean aliens - that entered the Mediterranean through the Suez Canal) and contraction
10459 of that of cold-water species, disrupt the present biogeographic patterns within the basin and place
10460 cold-water species under threat (Bianchi et al., 2012; B. Galil, Marchini, Occhipinti-Ambrogi, & Ojaveer,
10461 2017). In the past decade Erythraean aliens have increasingly been recorded on the deeper shelf (>
10462 80m) and even on the upper slope (Innocenti et al., 2017).

10463

10464 Attribution of biodiversity trends to direct drivers

10465 Recent increase of littoral residents, from 44 million in 2000 to 590 million expected in 2050, (Tosun,
10466 2011), and tourists: 270 million in 2010 to 346 million expected in 2020, coupled with intensification
10467 of anthropogenic activities, is driving unprecedented changes in the Mediterranean Sea (Micheli et al.,
10468 2013; EEA, 2015f). Habitat loss, environmental degradation and pollution are chronic and ubiquitous.
10469 Symptoms of complex and fundamental alterations to native populations, habitats and ecosystems
10470 proliferate, including increases in exotic species. The biota across wide swaths of the Mediterranean
10471 Sea, including marine protected areas, seagrass beds (Boudouresque, Bernard, Pergent, Shili, &
10472 Verlaque, 2009), algal mats, and biogenic reefs have already been severely altered (Airoldi and Beck,
10473 2007) with dire ecological, economical and human health impacts (Galil et al., 2015; Galil et al., 2017).
10474 Coastal lagoons are increasingly endangered by anthropogenic impacts (climate change, sea-level rise,
10475 massive introduction of invasive alien species, industrial scale aquaculture operations and fisheries) to
10476 the detriment of their role as a reservoir of genetic diversity (Pérez-Ruzafa, Marcos, & Pérez-Ruzafa,
10477 2011; Angel Pérez-Ruzafa & Marcos, 2012).

10478 Over half of all fish species are affected either directly or indirectly by fishing activities (Malak et al.,
10479 2011; Vasilakopoulos et al., 2014). Fishing, either through targeted or multi-species fisheries, is by far
10480 the most common threat to fish biodiversity, affecting 33% of native marine fish species, with an
10481 additional 18% threatened by by-catch. In the Mediterranean, 85% of the stocks are currently
10482 overfished and populations of many commercial species are characterized by truncated size- and age-
10483 structures (Colloca et al., 2013). Overfishing has also led to a reduction of genetic diversity outside
10484 marine protected areas (Pérez-Ruzafa, González-Wangüemert, Lenfant, Marcos, & García-Charton,
10485 2006). Larger coastal species and species that occur in areas subjected to prolonged or intensive fishing
10486 pressure are of particular concern (Malak et al, 2011). An analysis of the status of the Mediterranean
10487 fisheries (1970-2010), using various indicators (total landings, mean trophic level and fishing-in-
10488 balance index) confirmed that the fisheries resources of the Mediterranean are at risk from
10489 overexploitation. The pattern of exploitation and the state of stocks differed among the regions, with
10490 the eastern Mediterranean fisheries being in the worst shape, and declining (Tsikliras, Dinouli, Tsiros,
10491 & Tsalkou, 2015).

10492 The effectiveness of management initiatives implemented in the context of the European Common
10493 Fisheries Policy has been questioned with regard to the Mediterranean (Vasilakopoulos et al., 2014;
10494 Cardinale and Scarcella, 2017). However, some of the analyses that compare the fishing activity in the
10495 North East Atlantic and in the Mediterranean do not take into account some of the differentiating
10496 characteristics of each region, and fail to discuss the role of marine protected areas as a
10497 complementary management tool (Pérez-Ruzafa et al. 2017).

10498 Marine protected areas provide benefits not only for recovering target fish stocks, but also to
10499 biodiversity (Angel Pérez-Ruzafa et al., 2017), maintaining assemblage structure and ecosystem

equilibrium (Claudet et al., 2008; García-Charton et al., 2008; Lester et al., 2009; Guidetti et al., 2014; Sciberras et al., 2015) preserving ecologic interactions (Guidetti, 2006a, 2006b) and maintaining genetic diversity (Pérez-Ruzafa et al., 2006). These effects can take place in a relatively short time (Pérez-Ruzafa et al., 2015) and so the number of marine protected areas has been increasing significantly (see MAPAMED for trends in the Mediterranean, <http://www.medpan.org/en/mapamed>). There are 1,231 (7.14% of sea surface area) marine protected areas under legal designation in the Mediterranean, even if only 76 of those have no-go, no-take or no-fishing zones, that are the widest measures of protection for biodiversity (0.04% of sea surface area). A recent report (MedPAN and RAC/SPA, 2016) admitted that “... for the majority of sites little is known on whether management measures are implemented and if they are, whether these measures are effective to reach the sites’ conservation targets.” Surveys conducted in marine protected areas situated along the Levant coastline recorded large populations of mostly Erythraean exotic species (Sala et al., 2011; Yokes and Baki, 2012; Guidetti et al., 2014; RAC/SPA -UNEP/MAP, 2014; Vergés et al., 2014). These marine protected areas are “hot spots” of exotic biodiversity and serve as “seed banks” for secondary spread. A study by IUCN, WWF and MedPAN found “Uncertainty and lack of information regarding marine introduced species was high in the marine protected areas we surveyed, as in average half marine protected area (54.8%) managers did not know the status of the introduced species reported (there).” (Abdulla et al., 2008).

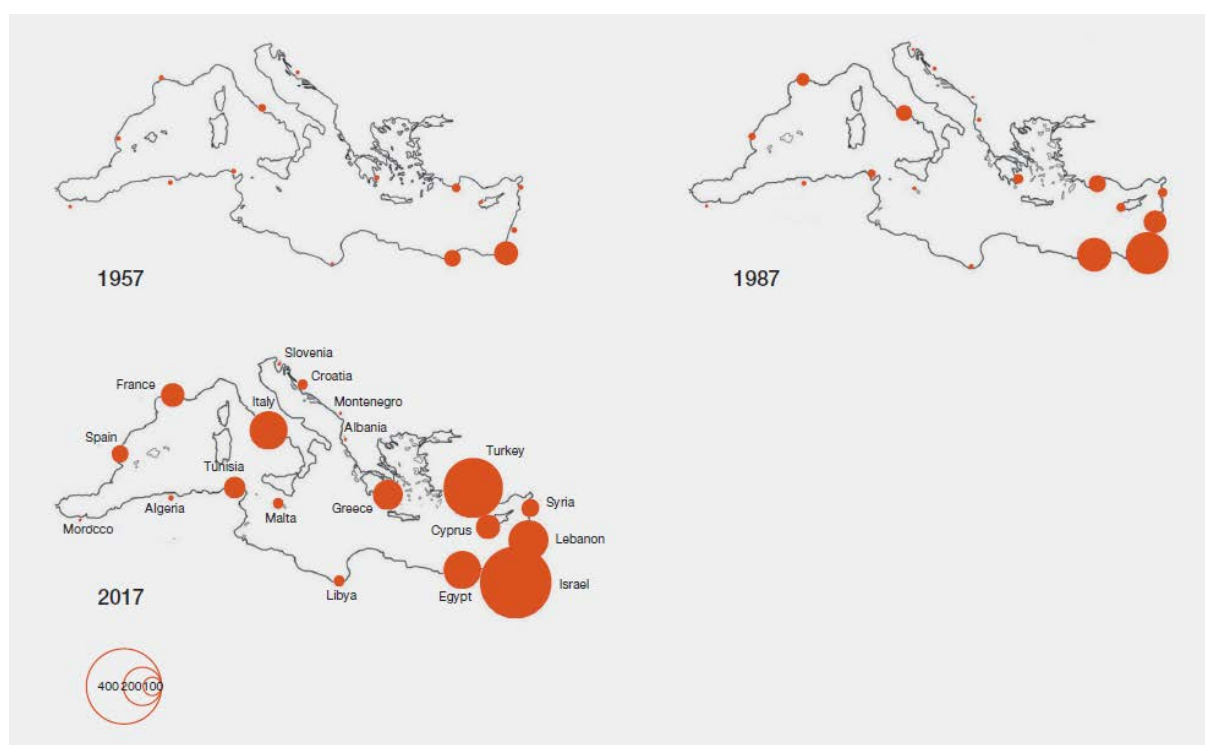


Figure 3.36: Number of alien species recorded in the coastal waters of the Mediterranean Sea in 1957, 1987, and 2017. Introductions through the Suez Canal account for the larger numbers in the Levantine Basin. (Galil, B.S., Marchini A., Occhipinti-Ambrogi A. 2017, unpublished)

The number of alien species, currently 740 multicellular species (Figure 3.36, with their distribution), is substantially greater for the Eastern than the Western Mediterranean Sea with new introductions registered on monthly basis (Galil et al., 2015; Galil et al., 2017). The most common vectors in the Mediterranean are the Suez Canal (60%) (Figure 3.36) and vessels (21%). The invasion of the “killer alga” *Caulerpa taxifolia* raised concern over its impact on *Posidonia* meadows (Bulleri & Piazzzi, 2014), on the trophic chain (Alomar et al., 2016; Deudero et al., 2011; Felling et al., 2014; Terlizzi et al., 2011),

10528 nutrient cycles (Gennaro, Piazzì, Persia, & Porrello, 2015), sediments (Balata et al., 2015), and sessile
10529 and motile biota.

10530 In the eastern Mediterranean algae-dominated rocky habitats, including *Cystoseira* meadows, have
10531 been decimated by large populations of herbivorous fish introduced through the Suez Canal. The two
10532 voracious grazers, *Siganus luridus* and *S. rivulatus* have transformed lush rocky reefs into “barrens”
10533 (Giakoumi, 2014; Sala et al., 2011; Vergés et al., 2014).

10534 The individual and cumulative impacts of these invasions adversely affect the conservation status of
10535 native species and critical habitats, as well as the structure and function of ecosystems and the
10536 availability of natural resources (Galil, 2007). Some species are noxious, poisonous, or venomous and
10537 pose clear threats to human health (Galil, Boero, et al., 2015).

10538

10539 3.3.4.4 The Black and Azov Seas

10540 Overview of the system

10541 The Black and Azov Seas are connected to the Mediterranean Sea by the Bosphorus and the Dardanelles
10542 Straits and the Sea of Marmara. The area of the Black Sea is 422,000km, with a maximum depth of
10543 2,210m and the mean depth is 1,240m (Dobrovolskii and Zalogin, 1982). It is very stratified (Vershinin,
10544 2003, 2016), with about 90% of its volume as anoxic water, saturated with hydrogen sulphide
10545 accumulated from decaying organic matter. The thin oxygen rich upper layer is about 10-15% of total
10546 water volume and only about 100-150m thick, but supports most of the unique biodiversity the Black
10547 Sea (BSC, 2008; Filippov, 1968; Murray et al., 1989; Yakushev, 1999). The deeper waters are inhabited
10548 mostly by protozoa, bacteria, and some multi-cellular invertebrates, though overall knowledge about
10549 its biodiversity is very limited (BSC, 2008). Recent publications estimate the number of Black Sea
10550 species at about 5,000 (Gomoiu et al., 2012).

10551 Two major rivers flow into the Sea of Azov: the Don and Kuban, and salinity is at its lowest (about 1‰)
10552 near the mouth of the Don (Kotlyakov, 2004). Flora and fauna are composed of different biogeographic
10553 groups with a predominance of eurythermic and euryhaline species. Only for the last 6,000-7,000 years
10554 the Black Sea has been connected to the Mediterranean basin and freshwater organisms gave place to
10555 marine life. Relicts contribute less than 5% of current species, whereas about 85% of the current
10556 species originate from the Mediterranean. Now there are about 700 species of phytoplankton, 150 of
10557 zooplankton, 300 macroalgae, 1500 benthic invertebrates and about 180 fish species and three marine
10558 mammals in the Black Sea (Vinogradov, 1958; Sorokin, 2002; Vershinin, 2003).

10559

10560 Past and current trends

10561 During the 1980s and early 1990s, the Black Sea ecosystem was in a severely degraded condition, being
10562 rated with highest concern in five out of seven environmental categories, and the worst of any of the
10563 European seas (Stanners and Boudreau, 1995). The deterioration of this ecosystem was the result of
10564 two main drivers: a) eutrophication caused by increase of phosphate and nitrate input from large rivers
10565 leading to changes in the silicon/phosphorous and silicon/nitrogen balance (Nesterova & Terenko,
10566 2009); and b) invasion by the ctenophore *Mnemiopsis leidyi*. This ctenophore, a competitor of
10567 planktivorous fishes, reached very high biomass levels ($>1 \text{ kg m}^{-2}$) (Kideys, 2002), devastating the food
10568 chain of the entire Black Sea basin. After the ctenophore bloom, there were sharp decreases in anchovy
10569 catch and in the biomass of non-gelatinous zooplankton across the Black Sea which lead to a
10570 simplification of the food web that consisted mainly of phytoplankton, gelatinous zooplankton and

10571 ctenophores and bacteria (**Figure 3.37**) (Shiganova et al., 2000; Stelmakh et al., 2012; Vinogradov et
 10572 al., 1995).

10573 Extinction of about half of the native bivalve species was brought about by the invasion of the Pacific
 10574 gastropod *Rapana venosa*, starting in 1947. Black Sea populations of *Ostrea edulis* and *Flexopecten*
 10575 *ponticus* are now on the brink of extinction (Sorokin, 2002; Vershinin, 2016; Zaitsev and Mamaev,
 10576 1997). The populations of predators such as dolphins, mackerel and tuna have declined because of
 10577 pollution and overfishing. Fishing has been refocused on the sprats *Sprattus* and *Clupeonella*, whose
 10578 population had also dramatically decreased by the early 1990s (Tokarev & Shulman, 2007).

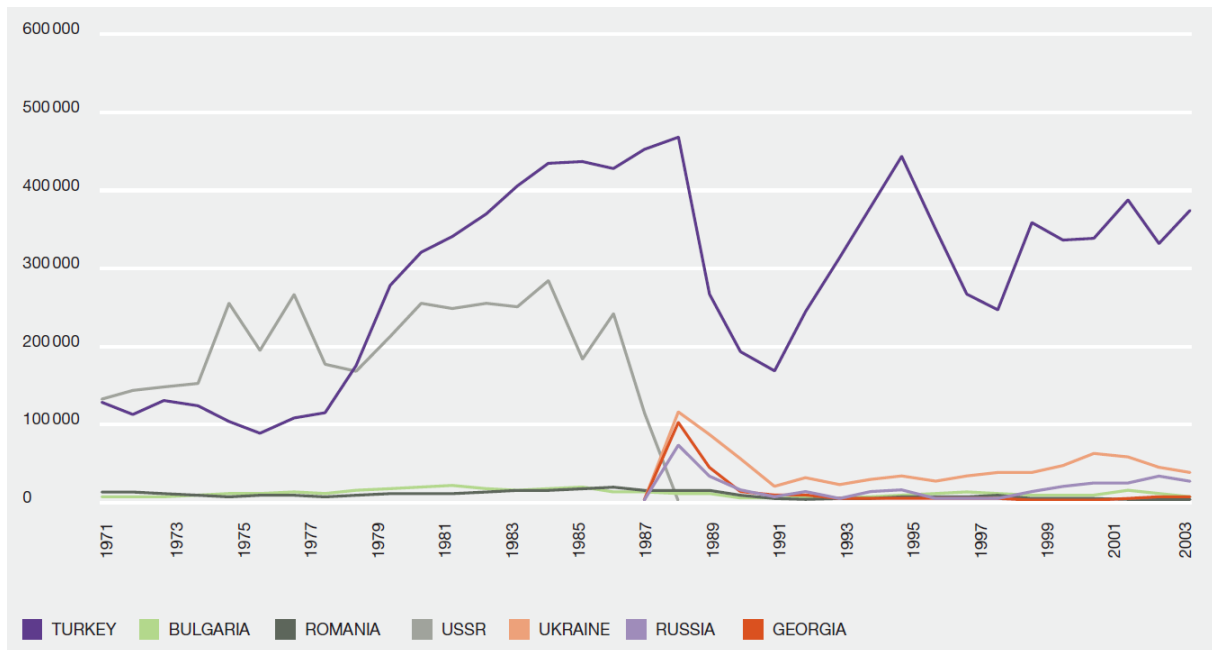
10579 Since the mid-1990s there have been some signs of ecosystem recovery. Western Black Sea coastal
 10580 waters improved due to reduced nutrient inputs, especially phosphorus (Kresin et al., 2008), mainly
 10581 due to the economic recession after the dissolution of the Soviet Union. This led to fewer microalgal
 10582 blooms, recovery of some algal populations, increasing plankton biodiversity, decreasing opportunistic
 10583 and gelatinous species, re-appearance of some native fodder zooplankton and fish species, and
 10584 increasing edible zooplankton biomass (Ogus, 2008). After 1992, several eutrophication indices also
 10585 improved in the eastern and deep Black Sea, indicating a more widespread recovery of the Sea (Kideys,
 10586 2002). Then, the ctenophore *Beroe ovata*, a specialized predator of *Mnemiopsis* was also introduced
 10587 into Black Sea leading to a sharp decline of *Mnemiopsis* followed by a sharp decline of *Beroe* itself. The
 10588 *Mnemiopsis* population crash and reduction of eutrophication led to increases in non-gelatinous
 10589 zooplankton, egg densities of anchovy, as well as increases in the biomass of two native gelatinous
 10590 cnidarians (*Rhizostoma pulmo* and *Aurelia aurita*) and anchovy landings. In the early 2000s the
 10591 concentration of zooplankton returned to the level before the invasion of *Mnemiopsis leidyi*. In 2004
 10592 in the north-eastern part of the Sea the number of species was comparable with numbers before the
 10593 invasion of *Mnemiopsis*. The total number of fish roe and especially fish larvae, however, remains
 10594 below the level of the 1960s (Tishkov, 2009).

10595 In the Azov Sea in 1950 to 1970 the construction of storage reservoirs and implementation of water
 10596 management led to a significant decrease in river inflow (Bespalova, 2016) and subsequent increase in
 10597 salinity (Kuksa, 1994). There was a migration of Black Sea species to the Azov Sea and the native
 10598 freshwater and brackish water ecosystems changed, with a decrease of commercial fish spawning in
 10599 the estuary systems. Pollution by heavy metals, organochlorine pesticides, and petroleum
 10600 hydrocarbons increased, leading to the reduction of productivity (Bespalova, 2016; Kotlyakov, 2004).
 10601 Annual migration of *Mnemiopsis leidyi* led to a decrease in zooplankton biomass (Khrustalev et al.,
 10602 2001; Mirzoyan et al., 2002) that caused damage to the anchovy and sprat populations, resulting in
 10603 the loss of commercial catch of these species.

10604 The first Black Sea Red Book (Dumont, Mamaev, & Zaitsev, 1999) included 160 endangered species. Of
 10605 those, sturgeons are the most endangered, along with species that inhabit shallow coastal waters such
 10606 as turbot, sharks, seals, shrimp and oysters. Several marine mammals and seabirds were also
 10607 considered to be threatened when their population size and distribution was assessed, with the
 10608 potential to become extinct in the near future (Eremeev et al., 2011). The habitats at risk include some
 10609 in the water column, lagoons, estuaries and deltas, and wetlands and saltmarshes. In a recent
 10610 assessment of 63 shallow water habitat types in the Black Sea, 86% of the habitats were considered
 10611 Data Deficient (Gubbay et al., 2016). Excluding those, 67% of habitats were classified as threatened,
 10612 including 11% as Critically Endangered.

10613 Phytoplankton and zooplankton ecological communities are currently recovering, but the communities
 10614 of higher trophic level species (benthonic species, fish) have not yet recovered. Commercial stocks of
 10615 anchovy are at a relatively high level, and stocks have recovered, but populations of the majority of

10616 anadromous and catadromous fishes, such as sturgeons, (Table 3.4) are still low and 70% of the
 10617 industrial fish catching consists of small pelagic fishes (Lukoyanov, 2013).



10618
 10619 **Figure 3.37: Total fish catches in the Black Sea, according to UN FAO data (ton/year) (Evolution of**
 10620 **the Black Sea Ecosystem, 2016)**

10621
 10622 Attribution of biodiversity trends to direct drivers

10623 Increased temperature of the upper mixed and the cold intermediate layers due to climate change
 10624 contributes to naturalization of thermophilic species from the Mediterranean Sea and thins the upper,
 10625 oxygen-rich layer of water in the Black Sea. Increase of temperature also causes increased evaporation
 10626 from the seawater surface and reduced inflow from rivers.

10627 Invasions as a result of introduction from ballast water have caused profound changes in the Black Sea.
 10628 There are 156 species naturalized in this basin (Shiganova, 2000; Shiganova et al., 2000). Invasive
 10629 species from the coastal Atlantic waters of North America, belonging to eurybiont marine organisms,
 10630 have the greatest influence.

10631 Twenty countries in Western, Central and Eastern Europe discharge industrial and household
 10632 wastewaters into the Black Sea basin. Moreover, the main pressure falls on the north-west shallow
 10633 part of the Black Sea, where the main spawning grounds and habitats of algae and benthic species, are
 10634 located. Drainage of agricultural lands and increase in mineral fertilizer flows led to the eutrophication
 10635 of waters and changes in the structure of communities. Nutrients coming from the Danube river
 10636 remained significant, but stable, in recent years (EEA, 2015f). Rice agriculture has a strong impact on
 10637 Azov Sea biodiversity (water balance and pollution of seawater). Water pollution by oil and oil-
 10638 products killed marine animals in the Azov and Black Seas (Diagelets et al., 2014).

10639 Fish stocks have deteriorated dramatically over the past three decades. The diversity of commercial
 10640 fish caught has decreased over this period from about 26 species to only six, although the volume of
 10641 fish caught has actually increased, after a near collapse in 1990. This is almost entirely due to significant
 10642 anchovy fishing by Turkey, accounting for almost 80% of the total catch. Illegal fishing is also increasing,
 10643 affecting biodiversity as well as the fishing industry (EEA, 2015f). Fishing gear is also responsible for a
 10644 decrease in non-target species. For example, dolphins are being stranded in lost or abandoned

fishnets, even inside marine protected areas (Nicolae et al., 2013; Radu and Anton, 2014; Zaharia et al., 2014).

Table 3.4: Average fish catching in the Azov district in the 20th century, ton/year

Fish	natural regime	after river regulation	
	1930-1940	1975-1982	1988-1989
anadromous:			
Acipenser guldenstadti	463	73	71
A. stellatus	684	17	7
Huso huso	276	15	5
Alosa caspia tanaica	1 508	97	47
Vimba vimba	233	15	11
Pelecus cultratus	3 696	475	376
catadromous and freshwaters:			
Lucioperca lucioperca	10 224	432	410
Abramis brama	20 353	912	1 960
Rutilus rutilus heckeli	770	18	11,6
Cyprinus carpio	895	2	6
Silurus glanis	1 200	2	0
Esox lucius	70	0	4
Others	2 730	2	20
Total:	43 102	2 060	3 033

3.3.4.5 Arctic Ocean

Overview of the system

The Barents, the White, the Kara, the Laptev, the East-Siberian, the Chukchi, and the Bering Seas together form the Arctic Seas of Europe and Central Asia. The region is a part of the Arctic biogeographic realm except some areas on its south-western and south-eastern margins which are temperate (Spalding et al., 2007). The most distinctive feature of the region is its ice-associated ecosystems.

Past and current trends

As the Eurasian Arctic Ocean is among the less studied marine regions of the world (Jorgensen et al., 2016) and monitoring data are sparse, the majority of observed variations are for the Barents, the White, the western Kara, the Bering, and the Chukchi Seas. While studies that speculate or attempt to forecast impacts of current climate change on Arctic marine biota are numerous, documented impacts are much more scarce (Wassman et al., 2011).

The generally observed and well documented trend of northward species' range shifts (including invasive species) has been defined in the western and the eastern parts of Eurasian Arctic as a processes of "Atlantification" and "Pacification" respectively (Fossheim et al., 2015b; Jørgensen et al., 2016). In particular, the invasive snow crab is rapidly spreading in the eastern Barents and the Kara Sea (Pavlov and Sundet, 2011; Zalota and Spiridonov, 2015), and other "warm-water" decapods are shifting north-eastward from respective biogeographical borderlines drawn decades earlier (Zimina, Lyubin, Jørgensen, Zakharov, & Lyubina, 2015). Consequences of this process could be unpredictable and different for the different ecosystems. For example, in the Chukchi Sea more nutritious copepods with

high fat content could increase; while in the Barents Sea less nutritious boreal copepods could replace their Arctic relatives (CAFF, 2017). At the same time there are observations showing increasing primary and secondary productivity in the Barents Sea (Dalpadado et al., 2014).

There are also different trends in species and abundance of Arctic fish in the northern Barents Sea (Johannesen et al., 2017). Overall there was a negative trend in the number of Arctic fish species from 2004-2015 but, while some species declined across the area, others declined only in the southern part and increased in the north, indicating displacement, while others did not show any significant change.

There are also changes in Arctic vertebrates' demography, abundance, distribution, phenology and community structure related to these processes (McRae et al., 2011) (**Figure 3.38**). Several marine mammal species are currently recovering from commercial exploitation (see also paragraph 3.4.3), which could mask reductions in carrying capacity associated with habitat loss in the short-term (Laidre et al., 2015).

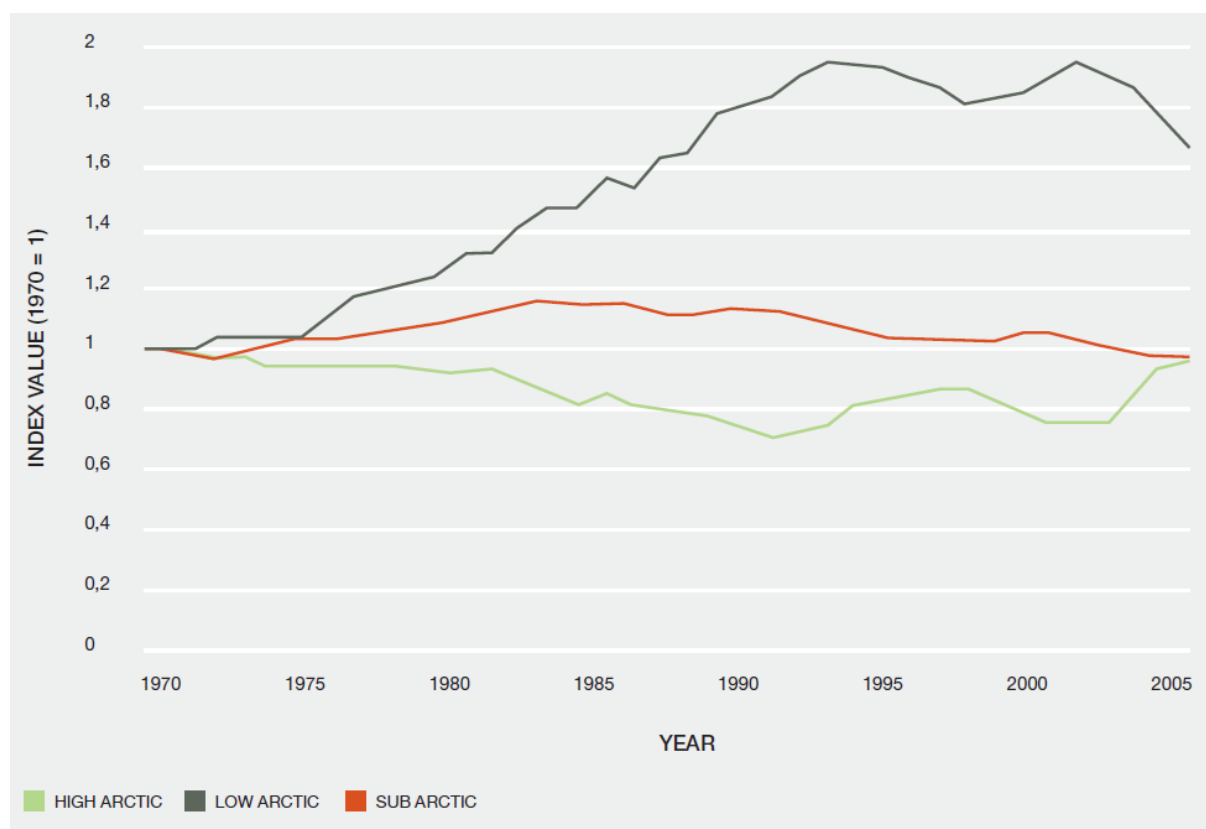


Figure 3.38: Index of abundance of Arctic vertebrate species from 1970 to 2007 grouped by high, low and sub-Arctic (Mc Rae et al., 2012, p. 8)

There is limited evidence of a decrease in benthic species biomass and diversity with increased pelagic grazing and recycling in the water column across the region (Kędra et al., 2015). In contrast, there are observations showing increase in biomass and diversity of the benthic communities in the Chukhchi Sea where Pacific species of polychaetes, crustaceans, mollusks, and bryozoans have been found in recent years (Sirenko & Gagaev, 2007), later research conducted in this region showed that, despite the presence of Pacific species in the area (e.g. northward shift and increased biomass of Walleye Pollock were observed in the Bering and the Chukchi Seas (Overland & Stabeno, 2004)), local benthic communities remained relatively stable (Sirenko, 2009).

Shrinking of multi-year ice cover and related increases of open waters and shelf seas caused a major decline in the productivity of sea-ice algae (Pabi, 2008; Wassman et al., 2011). Shifts in range and

seasonal movement patterns have altered predator-prey relationships, resulting e.g. in changes in diet of sea birds (Melltofte et al., 2013). Some arctic species have to travel more and expend more energy to find food. This can affect the condition of individuals and populations (CAFF, 2017). In the Barents Sea, the Chukchi Sea, and the Bering Sea, ecosystems are transforming from mostly ice-associated to more pelagic systems with changes in functional diversity (Wiedmann et al., 2014) and structure of food webs (Kortsch, Primicerio, Fossheim, Dolgov, & Aschan, 2015).

Attribution of biodiversity trends to direct drivers

The primary driver of the observed biodiversity change in the Arctic marine ecosystems is ongoing climate change, and in particular warming (Symon et al., 2005) and the decrease of sea ice. Current trends show that some species that are dependent on sea ice for reproduction, resting or foraging, are experiencing a reduction in range as sea ice retreats earlier and the open water season is prolonged (CAFF, 2017). This has been shown for many species, such as ducks breeding on the Siberian tundra and wintering at sea, which have now shortened their migration in response to declines in winter sea ice cover. Changes in sea ice conditions are probably also linked to changes of abundance and health of marine mammals, such as declines in the abundance of hooded seals, reduced body condition of Barents Sea harp seals, and changes in prey composition of bearded seals. Early sea ice retreat also reduces suitable breeding and pup rearing habitat for ringed seals. This negatively affects polar bears, which feed on ringed seals, as these conditions make them much more difficult to catch. The bears are thus shifting to prey on ground-nesting seabirds nests (Prop et al., 2015), potentially causing a decline on these bird populations.

Multi-year sea ice is disappearing and is being replaced by first-year sea ice. This is expected to cause shifts in ice algal communities with cascading effects on the ice-associated ecosystem. Decline in ice amphipod abundance was already seen around Svalbard since the 1980s, coinciding with declining sea ice conditions (CAFF, 2017).

Although climate change and its effects are the major drivers of change in the Arctic (Wassman et al., 2011), other drivers are also contributing (**Box 3.3; Table 3.5**). For many years both local communities and international fleets have harvested several species of fish, seabirds and marine mammals and some stocks of fishes, large whales and seals were reduced to a small fraction of their original population sizes. Their current trends are, therefore, still subject to recovery from past overexploitation, complicating the interpretation of observed trends and attribution to environmental drivers (CAFF, 2017). Sea ice has been limiting the areas for industrial-scale fisheries until now but as the ice retreats, there is potential for expansion of this activity into previously unfished areas. In the Barents Sea, declines in benthic biomass have been linked to the intensity of bottom trawling and this is likely also important in other parts of the Arctic (CAFF, 2017).

So far, there are few examples of invasive marine species becoming established in the Arctic. However, in the Barents Sea two large non-native crab species, the snow crab and the king crab, have become abundant and are affecting benthic communities (CAFF, 2017; Oug et al., 2011).

Finally, population sizes and trends of many migratory Arctic birds are influenced by overharvest, disturbance, and habitat loss outside the Arctic (Melltofte et al., 2013).

3.3.4.6 North West Pacific Ocean

Overview of the system

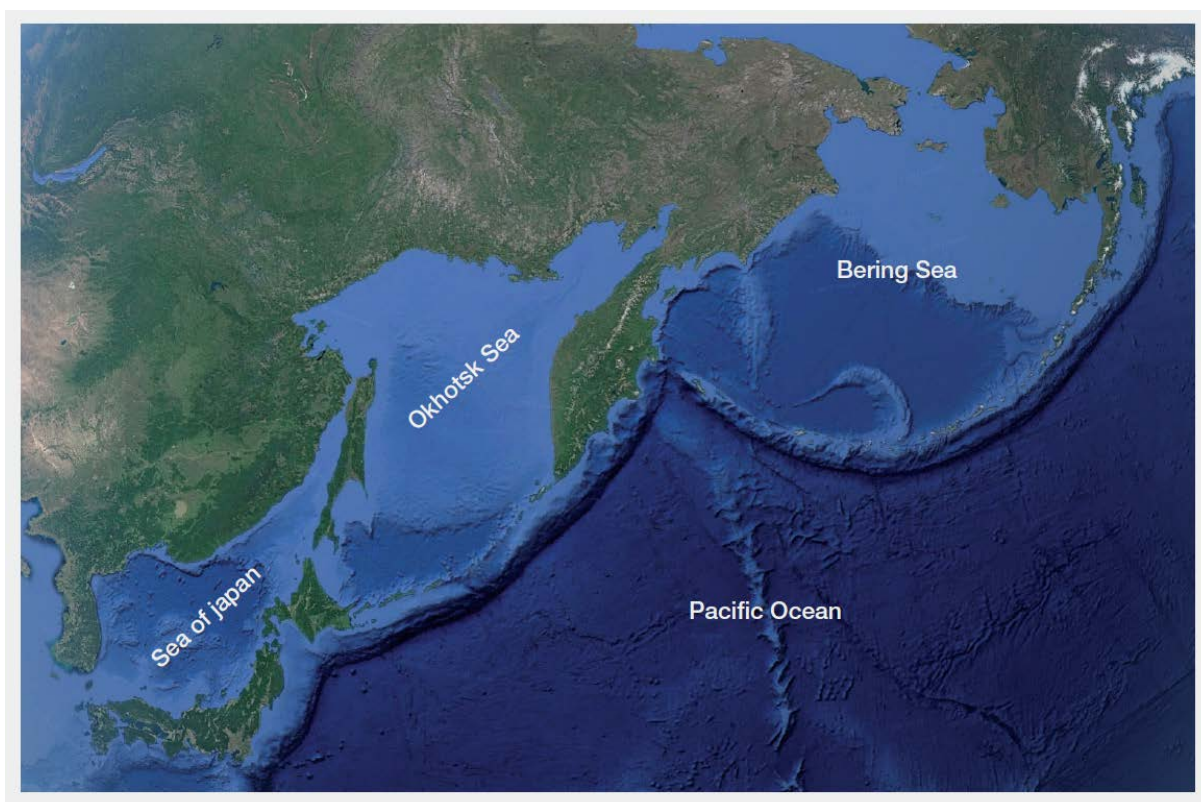


Figure 3.39: General chart of the North Western Pacific area.

The Russian Far Eastern seas, consisting of the western part of the Bering Sea, Okhotsk Sea and northern part of the Sea of Japan and the adjacent waters of the Pacific Ocean (**Figure 3.39**), have deep basins separated from the open ocean by chains of islands: Aleutian, Kuril and Japan Islands, that stretch from the Bering Strait to the coast of the Korean Peninsula (34° to 66° N). These are young basins with extensive development of recent metamorphic, volcanic and seismic processes. Natural hazards such as landslides in the coastal zone and continental slopes, earthquakes and volcanic eruptions that can cause tsunamis are widespread. This is one of the most highly productive regions of the global ocean with record levels of primary production equivalent to 70% of all Russian marine biological resources (Antonov et al., 2013) and important fishing areas with valuable marine animals and algae (**Figure 3.40**).

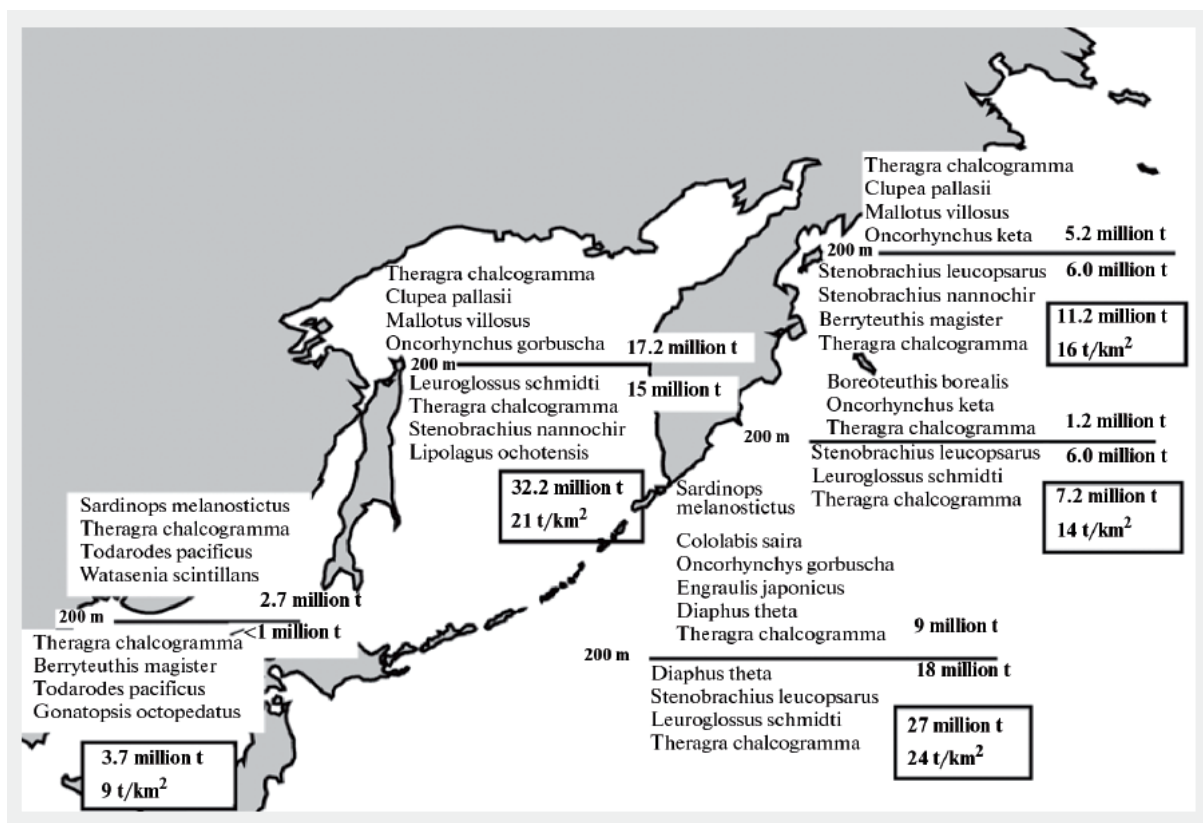


Figure 3.40: Mean annual composition of the most abundant nekton species and total nekton biomass in different regions of the Far Eastern Seas: numerator — in the epipelagic layer (0–200 m), denominator— in the mesopelagic layer (200–1000 m), in frame — total biomass (106 t) and concentrations (t/km²) of nekton (Shuntov & Temnykh, 2013)

In these waters, there are 37 species of marine mammals: 27 cetaceans, eight pinnipeds, the polar bear and the sea otter (Artyukhin et al., 1999; Burdin et al., 2009; Hunt, Katō and McKinnell, 2000; Geptner et al., 1976; Sokolov, 1986; Yablokov et al., 1972). The pelagic fishes in Russian waters of the Far Eastern seas and the Pacific Ocean comprise about 450 species, among which 114 species are identified in the Sea of Japan, 258 species in the Sea of Okhotsk, 170 species in the Bering Sea, and 319 species in the Russian waters of the Pacific Ocean. The average density of pelagic fauna in this area was calculated from about 20 years of trawl catches between 1980 and 2009, as an average of 16.8 tons/km² and a total resource of about 70–80 million tons (Ivanov & Sukhanov, 2015)(Figure 3.40).

The Sea of Japan is one of the most diverse seas in Europe and Central Asia. A total of 33,629 species have been reported to occur in these waters. The state of knowledge was extremely variable, with taxa containing many inconspicuous, smaller species tending to be less well known. The total number of species is estimated as 155,542, including 121,913 of identified but undescribed species reached. (Fujikura, Lindsay, Kitazato, Nishida, & Shirayama, 2010).

Past and current trends

After the dissolution of the USSR, production of commercial fish sharply decreased but since the beginning of the 21st century fishing volume has steadily increased. In 2012 the official catch was equal to 1.7 million tons (Antonov et al., 2013) (Figure 3.41). The volume of poaching is unknown. From 2006 to 2012 there was significant growth in catch, mainly of pollock, cod, herring, bluefish and lemonemy (*Laemonema longipes*) and the composition of the 2012 catch can be seen in Figure 3.41 (Shevchenko & Datsky, 2014).

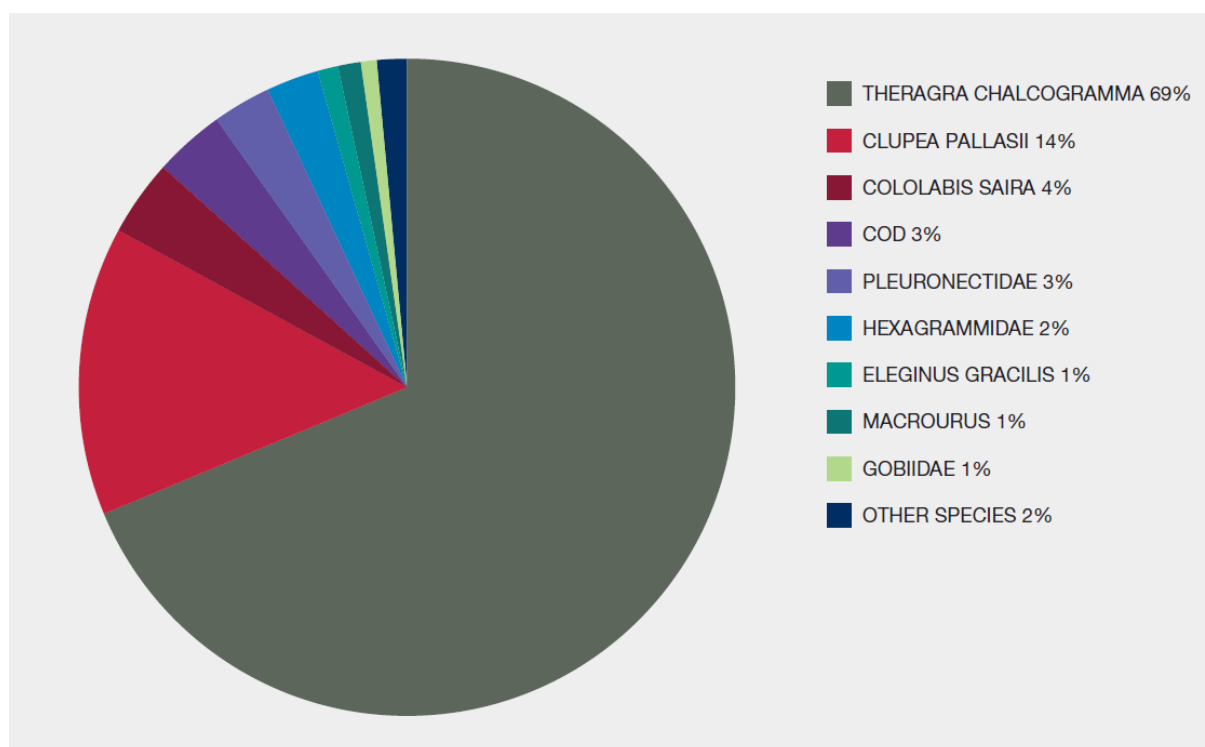


Figure 3.41: The composition of marine fish catch of the Far East seas in 2012 (tonnes;%) (Shevchenko & Datsky, 2014).

From 1930 through the 1970s benthic communities of the Amur Bay have changed dramatically because of pollution: the number of polychaetes has decreased between 5-10 times, brittle stars 2-3 times, the average biomass of benthos by one third. Stocks of Gray's mussels have diminished, and the number and growth rate of scallops have drastically decreased. The stocks of commercial seaweeds (*Ahnfeltia*) decreased – from 86.5 to 40 thousand tons from 1961 to the present time (Belan, 2003). The number of polychaetes, tolerant to low oxygen conditions increased (Belan, 2003). Mass mortalities of small fish have occurred (Yablokov, Koltsov, Levchenko, Sechenov, & Kerzhentsev, 2014).

The Okhotsk-Korean population of grey whales is one of the most vulnerable in the world. It is included into the Red List of threatened species as "Critically Endangered" (IUCN, 2015) and is in the Russian Red Book. The reason for its decline in the past was whaling, while in the present day intensive exploitation of oil and gas deposits on the shelf near Sakhalin Island threaten destruction of the population on its the summer-autumn feeding grounds (Adrianov, 2011). The far Eastern seas are important for the Russian economy due to the discovery of large oil and gas reserves on the Far Eastern shelf. However, after an agreement between NGOs and an oil company, mitigation plans for the company exploitation were agreed and followed and the number of whales increased from about 115 animals in 2004 to 174 in 2015 (Martin-Mehers, 2016).

In the waters of the Gulf of Peter the Great 32 potentially harmful species of microalgae capable of producing biotoxins were discovered (Adrianov & Tarasov, 2007). Recently blooms of strains of microalgae that are highly pathogenic and highly virulent have appeared and accumulations of dangerous microorganisms in filter-feeding organisms may lead to a threat to human health (Adrianov & Tarasov, 2007) (Figure 3.42).

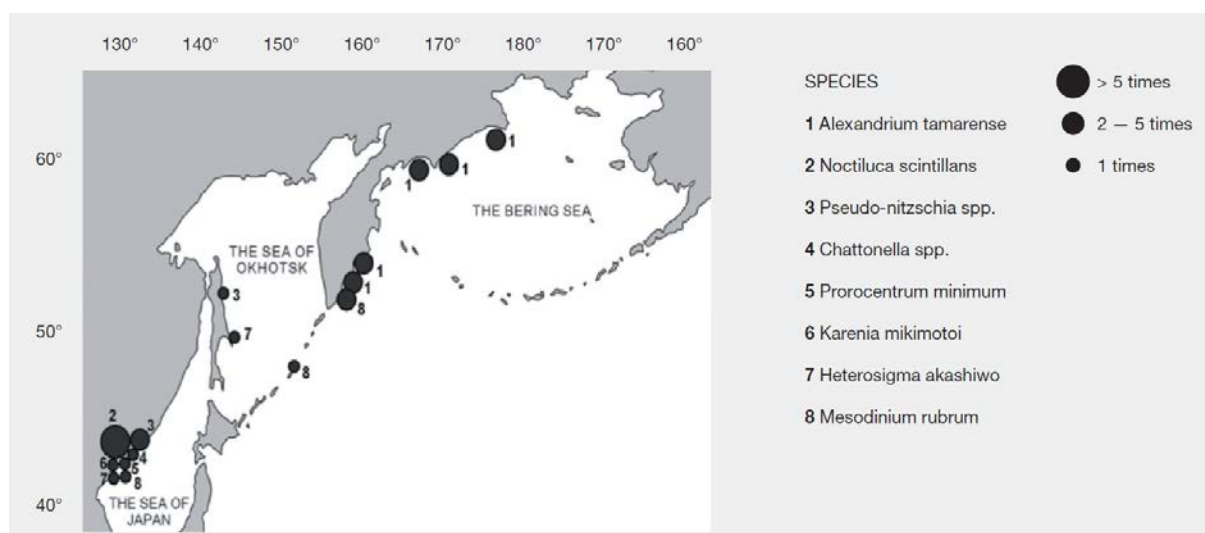


Figure 3.42: Harmful algal blooms in the Far East seas of Russia in 1980-2005 (Orlova et al., 2002)

312 invasive species were found in Peter the Great Bay, including 104 southern migrants, most of them were transported in ballast waters. In the last 12 years 19 new tropical and subtropical species were detected (Adrianov, 2011). The expansion to the north of not only individual species, but entire complexes of the southern biota is one of the consequences of climate change (IPCC, 2014b).

Attribution of biodiversity trends to direct drivers

Fishery is the main pressure on the North West Pacific Ocean's biological diversity. The total catch every year reaches several million tons of fish and invertebrates. Before 1990, the Soviet Union provided more than half of the world's total catch of pollock (about 2.5 million tons) (FAO, 2011). Excessive fishing of species such as crab, cod, pollock and others, and the by-catch of non-target fish lead to the loss of fishing activities, e.g. the loss of Far Eastern crab fisheries (Adrianov, 2011).

A fast reduction of sea ice (4% of the sea area per decade) was recorded in the Okhotsk Sea in the period of 1957-2012 (Roshydromet, 2014). Thirty-three years of observations (1979-2011) showed that the air temperature above the water surface in the Sea of Japan had increased by 0.27° C. In the last 50 years the average temperature of surface waters in the Peter the Great Bay have increased by nearly 0.6° C and the amount of precipitation in the Far Eastern Seas has decreased (Roshydromet, 2014). This creates favourable conditions for invasive species (Adrianov, 2011). An assessment performed by PICES (The North Pacific Marine Science Organization) (Kestrup et al., 2015) found 208 NIS (Non-indigenous Aquatic Species) for the North West Pacific, introduced mostly by ballast water, hull fouling, the aquatic animal and plant trade or aquaculture.

Areas of the North West Pacific are impacted by pollution by oil products from oil and gas extraction on the shelf. Draining of fuel in ports and along the transportation routes, and dumping of decommissioned ships in the coastal zones is a very significant source of pollution in these waters. Their effects on marine biota are severe, including oil films on the surface poisoning birds and other animals, and disrupting photosynthesis and oxygen exchange with the atmosphere (Yablokov et al., 2014).

Excessive run-off of nutrients (nitrogen, phosphorous) from land causes eutrophication leading to hypoxia and the degradation of water ecosystems (Yablokov et al., 2014). Also, marine farming of fish and invertebrates harms the ecosystems at the local level degrading habitats and increasing pollution

10835 from organic waste, leading to the deterioration of water quality and a drop in farm productivity. The
 10836 area affected by pollution can be tens of times greater than the area of the farm (Vyaznikova, 2014).

10837

10838 *3.3.4.7 Deep-sea in Europe and Central Asia*

10839 Overview of the system

10840 The deep-sea is usually defined as those parts of the ocean deeper than 200m (Gage & Tyler, 1991)
 10841 beyond the edge of the continental shelf. It is the largest biome on earth, covering approximately 60%
 10842 of the Earth's solid surface. In the Europe and Central Asia region, the deep-sea covers an area greater
 10843 than 15 million km², encompassing 8 pelagic and 37 benthic biogeographic provinces (UNESCO, 2009)
 10844 and 11 hydrothermal vent provinces (Rogers et al., 2012). Due to its limited accessibility, it is the least
 10845 understood, yet one of the richest ecosystems on the planet supporting a high diversity of habitats
 10846 (e.g. deep-sea pelagic habitats, continental slopes, abyssal soft sediments plains, seamounts, mid
 10847 ocean ridges, deep-sea canyons and trenches, and smaller habitats such as hydrothermal vents, cold
 10848 seeps, or cold water coral reefs) and species, as well as a set of supporting and regulating functions
 10849 and services (Thurber et al., 2014).

10850

10851 Past-and current trends

10852 The Millennium Ecosystem Assessment recognized more than 10 years ago that enormous deep-sea
 10853 species richness remains undiscovered (Millenium Ecosystem Assessment, 2005), and this is still true
 10854 today (Mengerink et al., 2014). While there is a solid understanding of biodiversity changes in many
 10855 coastal ecosystems, trends in the deep sea are poorly described (Millenium Ecosystem Assessment,
 10856 2005), and even basic ecological information (e.g., species ranges, population subdivision, population
 10857 genetic diversity, dispersal capability and demographic parameters) is lacking for the vast majority of
 10858 species (Taylor & Roterman, 2017).

10859 However, changes in biodiversity and abundance have been reported as a result of deep-sea fishing
 10860 activities, oil spills, climate change, and other activities (Koslow et al., 2016). Also declines in cold-
 10861 water coral and deep-sea sponge abundance and community structure have been widely reported,
 10862 including off Norway, in the Barents Sea, the Azores, and other regions (Clark et al., 2016; Pham et al.,
 10863 2014).

10864 Recent changes in climate (5-16 years) in the deep-sea changed benthic species diversity, abundance
 10865 and faunal composition (Glover et al., 2010). This biodiversity loss in deep-sea ecosystems has been
 10866 shown to produce exponential reductions of ecosystem functions (Danovaro *et al.*, 2008) (see Section
 10867 3.2).

10868 Although trends are based on a very limited portion of the deep-sea (Koslow et al., 2016), they indicate
 10869 increased habitat degradation, and declines in biodiversity, abundance and probably ecosystem
 10870 functioning (Baldrighi, Giovannelli, D'Errico, Lavaleye, & Manini, 2017). This may also mean that the
 10871 achievement of important Aichi Biodiversity Targets may be compromised. Targets 5, 6 and 10 under
 10872 the Strategic Goal B of the Strategic Plan for Biodiversity 2011-2020, and Target 11 under Strategic
 10873 Goal C may require additional attention and management measures in this context. This may include
 10874 more effective fisheries management, and an increase of protected areas in the deep-sea and other
 10875 area-based conservation measures.

10876

10877 Attribution of biodiversity trends to direct drivers

10878 Although humans utilized the oceans for millennia, only recently, through technological developments,
 10879 deep-sea exploitation has begun. The past century has seen a significant increase in human activities

10880 that directly affect deep-sea ecosystems, including fishing, waste disposal, oil and gas extraction and
 10881 bio-prospecting (Morato, Watson, Pitcher, & Pauly, 2006; Pham et al., 2014; Ramirez-Llodra et al.,
 10882 2011; Sandrea & Sandrea, 2010; Synnes, 2007). Added to these pressures are indirect effects caused
 10883 by global climate change (Ramirez-Llodra et al., 2011).

10884 Bottom fishing has been the major driver of past ecosystem changes in the deep-sea (Clark et al., 2016).
 10885 It has modified seafloor morphology and its physical properties (Puig et al., 2012), produced
 10886 overfishing of many stocks, and produced extensive damage to benthic communities, many of them of
 10887 Vulnerable Marine Ecosystems (VME) (Clark et al., 2016; Hall–Spencer, Allain and Fosså, 2002; Pham
 10888 et al., 2014).

10889 Global landings of marine deeper water species have increased over the last 50 years (Morato et al.,
 10890 2006; Watson & Morato, 2013). Many of these fisheries have been overfished or depleted (reviewed
 10891 in Norse et al., 2012). Bailey et al., (2009) and Godbold et al., (2013) analysed scientific trawl data from
 10892 1977 to 2002 in the Porcupine region of the North East Atlantic deep sea and found a significant
 10893 decrease of 36% in fish biomass in fished depths and considerably deeper.

10894 Decline in deep-sea benthic invertebrate diversity (reviewed by Clark et al., 2016) has been observed
 10895 as a consequence of deep-sea fishing in the Barents Sea, and other regions.

10896 Although evidence has been found from the geological record that past climate change has impacted
 10897 deep-sea faunas, the evidence that recent climate change or climate variability has altered deep-sea
 10898 benthic communities is still limited (Glover et al., 2010). This mainly reflects the lack of observations
 10899 and monitoring of this vast seafloor habitat.

10900 Additionally, new industrial activities in the deep-sea are emerging, including the extraction of gas
 10901 hydrates, carbon sequestration, and mining. Future deep-sea mining (Petersen et al., 2016) has the
 10902 potential to disturb hundreds of thousands of km² of seabed and pelagic environment, with uncertain
 10903 consequences (Levin et al., 2016). The recent discovery of microplastics in deep-sea sediments
 10904 suggests that this emergent form of pollution is more far reaching than previously anticipated (Van
 10905 Cauwenberghe, Vanreusel, Mees, & Janssen, 2013).

10906

10907 *3.3.4.8 Progress towards goals of Multilateral Environmental Agreements*

10908 ***Aichi Biodiversity Target 11 and Sustainable Development Goal 14, target 14.5***

10909 **Subtarget “At least 10 per cent of coastal and marine areas are conserved (in marine protected 10910 areas)”**

10911 The definition of marine protected area varies significantly (e.g. Costello and Ballantine, 2015), which
 10912 causes divergence in the numbers presented as percentage of marine protected area coverage both
 10913 globally and regionally. In Europe and Central Asia, the coverage of marine protected areas was
 10914 calculated as 4% of its marine area (within the “exclusive economic zone” of 200 nautical miles) by
 10915 Brooks et al., (2016) and as 5,3% calculated by the present assessment with 2017 numbers from the
 10916 Convention on Biological Diversity (CBD, 2017).

10917 Within Europe and Central Asia, significant differences occur in terms of coverage both between the
 10918 different regional seas and the coverage of coastal waters and off-shore, within the exclusive economic
 10919 zone of coastal states. Marine protected area networks cover more than 5.9% of the European Union
 10920 marine area but only about 3% of Russian Federation marine waters. On the other hand, in European
 10921 Union countries more than 16% of coastal marine areas are now have some form of protection but,
 10922 beyond 12 nautical miles from the shore, an area representing 80% of the European Union's total sea
 10923 area, only 3% are protected.

10924 In the framework of regional agreements such as OSPAR (see below), HELCOM (see below), the
 10925 Bucharest and Barcelona Conventions, and the Arctic Council there have been significant advances
 10926 regarding the area covered by marine protected areas, including in “areas beyond national
 10927 jurisdiction”, and the integration of these marine protected areas in regional networks.

10928 The OSPAR network comprises 448 marine protected areas, covering 5.9% of the OSPAR maritime area,
 10929 including 16,7% of its coastal waters; 2,3% of the exclusive economic zones (EEZs) of OSPAR countries;
 10930 and seven marine protected area situated in areas beyond national jurisdiction covering 8.9% of this
 10931 OSPAR area (OSPAR, 2017a). Marine protected area coverage also varies geographically, covering
 10932 14.7% of the Greater North Sea but only 1.9% of the Arctic OSPAR area.

10933 The HELCOM marine protected area network from the Baltic Sea was the first in the world, already in
 10934 2010, to reach the target of conserving at least 10 % of coastal and marine areas. But although today
 10935 this network covers 11,8 % of the Baltic Sea, protection is not evenly distributed between sub-basins
 10936 or between coasts and open sea, and the aim remains to reach the 10% target in all offshore sub-basins
 10937 (HELCOM, 2017e).

10938 In the Mediterranean 1,231 marine protected areas and “other effective area-based conservation
 10939 measures” now cover 7.14 % of the Sea area, through a large variety of conservation designations, but
 10940 with the “no-go”, “no-take” or “no-fishing” zones accounting only for 0.04% (MedPAN and RAC/SPA,
 10941 2016). Coverage is very uneven in geographic terms: over 72.77% of the surface covered is located in
 10942 the western Mediterranean. Designations cover 9.79% of European Union waters mostly due to the
 10943 Natura 2000 at sea network. To reach the Aichi Biodiversity Target 11 of 10% of marine areas
 10944 protected, an additional 71,900 km² (2.86 % of the Mediterranean) will have to be designated. To also
 10945 fulfill the representivity goal, these new designations should target currently under-represented
 10946 features and subregions (MedPAN and RAC/SPA, 2016).

10947 The extent of protected areas in the Arctic’s marine environment has almost quadrupled since 1980
 10948 and represents today 4.7% of the Arctic marine area (CAFF, 2017). The marine protected area is
 10949 dominated by several very large areas and some parts of the Arctic marine ecosystem are still poorly
 10950 protected. In 2013, the Arctic Council adopted a resolution to identify “Areas of heightened ecological
 10951 and cultural significance” similar to the Convention on Biological Diversity’s “ecologically and
 10952 biologically significant areas” criteria. Through this process, 98 areas were identified covering about
 10953 76% of the Arctic marine area. These areas were identified primarily on the basis of their ecological
 10954 importance for fish, birds or marine mammals (CAFF, 2017). Approximately 5% of “areas of heightened
 10955 ecological importance” lie within the present protected areas.

10956 An effort to achieve the Aichi Biodiversity Target 11 of 10% has led to a significant increase in number
 10957 and extent of marine protected areas of different kinds in Europe and Central Asia in recent years, (e.g.
 10958 in OSPAR it went from 159 in 2010 to 448 in 2016 and from 1,06% of the areas in 2010 to 5,9 in 2016,
 10959 (OSPAR, 2017a) and in the Mediterranean 397 new marine protected areas were designated between
 10960 2012 and 2016). The general trend in marine protected area designation is therefore very positive. In
 10961 2017, 15 coastal nations have already more than 10% of their marine waters protected (CBD, 2017).

10962 Global conservation targets based on area alone will, however, not optimize protection of marine
 10963 biodiversity, and the emphasis should be on better marine protected area design, adequate
 10964 management and compliance to ensure that they achieve their desired conservation value. Edgar et
 10965 al., (2014) showed that the conservation benefits of marine protected area increased significantly with
 10966 the accumulation of five key features: no fishing allowed, well enforced, old (>10 years), large
 10967 (>100km²), and isolated by deep water or sand. These were also shown to be key features in the
 10968 Mediterranean, (Giakoumi et al., 2017), although here some small but well managed marine protected

10969 area were also effective in conservation.

10970

10971 **Subtarget “Protected areas are ecologically representative and well connected and include areas of**
 10972 **particular importance for biodiversity and ecosystem services conserved”**

10973 Since there is so much difference between coverage of marine protected area in open seas and in
 10974 coastal waters, ecological representativeness is still not achieved in Europe and Central Asia. In OSPAR
 10975 progress was made in recent years towards an ecologically coherent and well-managed network, but
 10976 further work is required to achieve this goal (OSPAR, 2017a). This network is well distributed in the
 10977 Greater North and Celtic Seas, but substantial gaps remain in Arctic Waters and the wider Atlantic
 10978 Ocean. Also 19 of the 54 OSPAR listed features (i.e. species or habitats) are already protected by more
 10979 than one marine protected area in those parts of the North East Atlantic where they are considered to
 10980 be at risk. This includes all five listed invertebrates, three of the seven bird species, one of the two
 10981 reptile species, one of the three marine mammal species, five of the 22 fish species and four of the 15
 10982 types of habitat.

10983 The HELCOM assessment of ecological coherence (HELCOM, 2016) showed that the areal
 10984 representation of different types of broad-scale habitats and the replication of a set of indicative
 10985 species and biotope were at an acceptable level for supporting a coherent marine protected area
 10986 network. However, connectivity, which measures how well the network supports the migration and
 10987 dispersal of species, is not yet optimal.

10988

10989 **Subtarget “Protected areas are effectively and equitably managed”**

10990 For many of the marine protected areas in waters of Europe and Central Asia, management plans
 10991 either do not exist; or knowledge on the implementation of protective measures or the effectiveness
 10992 of these measures to reach the sites’ conservation targets is insufficient (MedPAN and RAC/SPA, 2016).
 10993 Only a small percentage is known to have reached or to be moving towards the objectives they were
 10994 set up to attain. The resources needed to adequately implement the existing regulations and to
 10995 manage pressures inside and outside of marine protected areas are still very often not in place.

10996 Information on management is available for 61% of OSPAR marine protected areas, with a further 16%
 10997 partially documented. But management measures have been implemented for only 12% of OSPAR
 10998 marine protected areas, with partial action for a further 54%. The situation is similar for monitoring,
 10999 implemented only for about 14% of these marine protected areas (OSPAR, 2017a). So only 11% of
 11000 OSPAR marine protected areas were found to be moving towards or have achieved their conservation
 11001 objectives.

11002 Implementation of management actions for OSPAR marine protected areas in “areas beyond national
 11003 jurisdiction” have started by OSPAR member countries, but successful management requires
 11004 cooperation with international organisations with competence for the management of human
 11005 activities, such as fishing, shipping and deep-sea mining. A mechanism to help cooperation between
 11006 the relevant organisations has been started between OSPAR and the Northeast Atlantic Fisheries
 11007 Commission, referred to as “the collective arrangement” (OSPAR, 2017a). On-going negotiations
 11008 within the United Nations on the conservation and sustainable use of marine biological diversity in
 11009 areas beyond national jurisdiction (so called “BBNJ process”) is expected to result in a new
 11010 implementing agreement under the United Nations Law of the Sea that will finally allow marine
 11011 protected areas in “areas beyond national jurisdiction” to be adequately managed.

11012 HELCOM is now working towards the development of a method to assess the management
 11013 effectiveness of HELCOM marine protected areas and of the network. Such an assessment will

11014 determine the environmental positive effects of the marine protected area management (HELCOM,
11015 2017e).

11016 Many sites of the current system of marine protected area and “other effective area-based
11017 conservation measures” in the Mediterranean Sea do not have regulations in place to curb existing
11018 pressures or enough means to enforce them. Information about management measures and their
11019 effectiveness in maintaining or restoring biodiversity is also lacking. Resources allocated to
11020 management are not sufficient for the requirements, thereby compromising successful conservation
11021 (MedPAN and RAC/SPA, 2016).

11022

11023 **European Union Marine Strategy Framework Directive**

11024 **Progress towards the European Union Marine Strategy Framework Directive goals**

11025 The European Union Marine Strategy Framework Directive, approved in 2008, has as its main objective
11026 to achieve good environmental status in all waters of the European Union by 2020 (EEA, 2015f). This
11027 status is described through 11 descriptors including: biodiversity, non-indigenous species,
11028 commercially exploited fish, food-webs, eutrophication, sea-floor integrity, hydrographical conditions;
11029 contaminants in the environment, contaminants in seafood, marine litter, and energy, all relevant for
11030 determining the status of marine biodiversity and ecosystem functioning. The Directive aims to
11031 maintain or restore biodiversity and to attain a marine environment that is healthy, clean, and
11032 productive in all the European Union Seas and Ocean areas, and those it shares with its neighbors. Its
11033 implementation should also make significant contributions to achieving the goals of the European
11034 Union Biodiversity Strategy for the marine environment.

11035 The first assessment of Europe's seas at European Union-wide scale (EEA, 2015f) used data from the
11036 first Marine Strategy Framework Directive and Habitats Directive's reporting completed in 2012 and
11037 other sources. 80% of the species and habitats assessments under the Marine Strategy Framework
11038 Directive were categorized as 'unknown' status, but a more complete picture is available for the marine
11039 habitats and species protected by the Habitats Directive. Even for species and habitats with
11040 conservation interest, only 9% of the habitats assessed were considered to have 'favourable
11041 conservation status', 66% were considered to be in 'unfavourable conservation status' and 25% were
11042 categorized as 'unknown'. For marine species only 7% assessed were considered to have 'favourable
11043 conservation status', 66% were categorized as 'unknown' and 27% were categorized as having
11044 'unfavourable' status. Additionally, 58% of the assessed commercial stocks did not have 'good
11045 environmental status', while the status of 40% of commercial fish stocks was not assessed due to lack
11046 of data.

11047 There are many 'unknowns' when it comes to European Union member State reporting and in
11048 commercial fish stock statistics data from mandatory reporting. This highlights the difficulty associated
11049 with obtaining data to assess the health status of even the seas that are under European Union
11050 responsibility, where relatively rich information exists. However, by comparing information available
11051 from European, regional, and national sources, a common pattern of change can be seen: ecological
11052 extinctions are being observed across species belonging to different functional groups including
11053 species such as monk seals in the Black Sea, bluefin tuna in the eastern North Sea, sharks in the
11054 Mediterranean Sea and North East Atlantic Ocean and habitat-forming species like oysters in the North
11055 Sea and sea grasses in the Baltic and Mediterranean Seas. Even if there are a few examples of species
11056 where the declining trends appear to be halted, such as for bluefin tuna (*Thunnus thynnus*) in certain
11057 areas (EEA, 2015f), patterns of degradation are observed across all of the ecosystem components, and
11058 across all of the information sources considered. The observed loss of biodiversity affects ecosystem
11059 functioning and may cause irreversible loss of ecosystem resilience, putting in jeopardy ecosystem

11060 health. Based on different assessments considered the European Union’s marine ecosystems could
 11061 therefore not be considered to be in a healthy state, as would be the objective of the Marine Strategy
 11062 Framework Directive.

11063 The European Environment Agency (2015e) considered in addition that European Union marine areas
 11064 could also not be considered clean, even though some improvements in eutrophication are already
 11065 visible, for example in the Black and Baltic Seas. It stated, however, that they could be considered
 11066 productive, thus fulfilling one of the three main goals of the Marine Strategy Framework Directive.

11067 Even if this Directive is only valid in the European Union , member States are required to use existing
 11068 regional cooperation structures to co-ordinate among themselves and to make every effort to
 11069 coordinate their actions with those of third countries in the same region or subregion. This cooperation
 11070 has been taking place through OSPAR, HELCOM, the Barcelona and Bucharest Conventions for more
 11071 than 30 years, and is also done in the framework of the Arctic Council.

11072 **Box 3.3: Summary of past and current trends in biodiversity and ecosystems and their attribution to**
 11073 **direct drivers of change.**

11074 The table and figure of this box summarize past and current trends in biodiversity and ecosystems for
 11075 terrestrial and inland surface water units of analysis and marine areas in Europe and Central Asia and
 11076 the attribution of these trends to direct drivers of change. **Table 3.5** presents the assessed information
 11077 in terms of trends in areal extent (3.4) and biodiversity status. Biodiversity status summarizes the
 11078 biodiversity information assessed in 3.3 and 3.4. **Figure 3.43** summarizes the trend information on
 11079 biodiversity status graphically, where “Weighted” denotes graphs for which the units of analysis were
 11080 weighted by their area, and “Unweighted” denotes graphs where units of analysis were given equal
 11081 weight.

11082 **Table 3.5. Summary of past and current trends in biodiversity and ecosystems in terms of spatial**
 11083 **extent and biodiversity status for terrestrial and inland surface water units of analysis and in terms**
 11084 **of biodiversity status for marine systems, and summary of the attribution of these trends to direct**
 11085 **drivers of change. WE, CE and EE denote Western, Central and Eastern Europe, CA denotes Central**
 11086 **Asia, and ECA denotes Europe and Central Asia.**

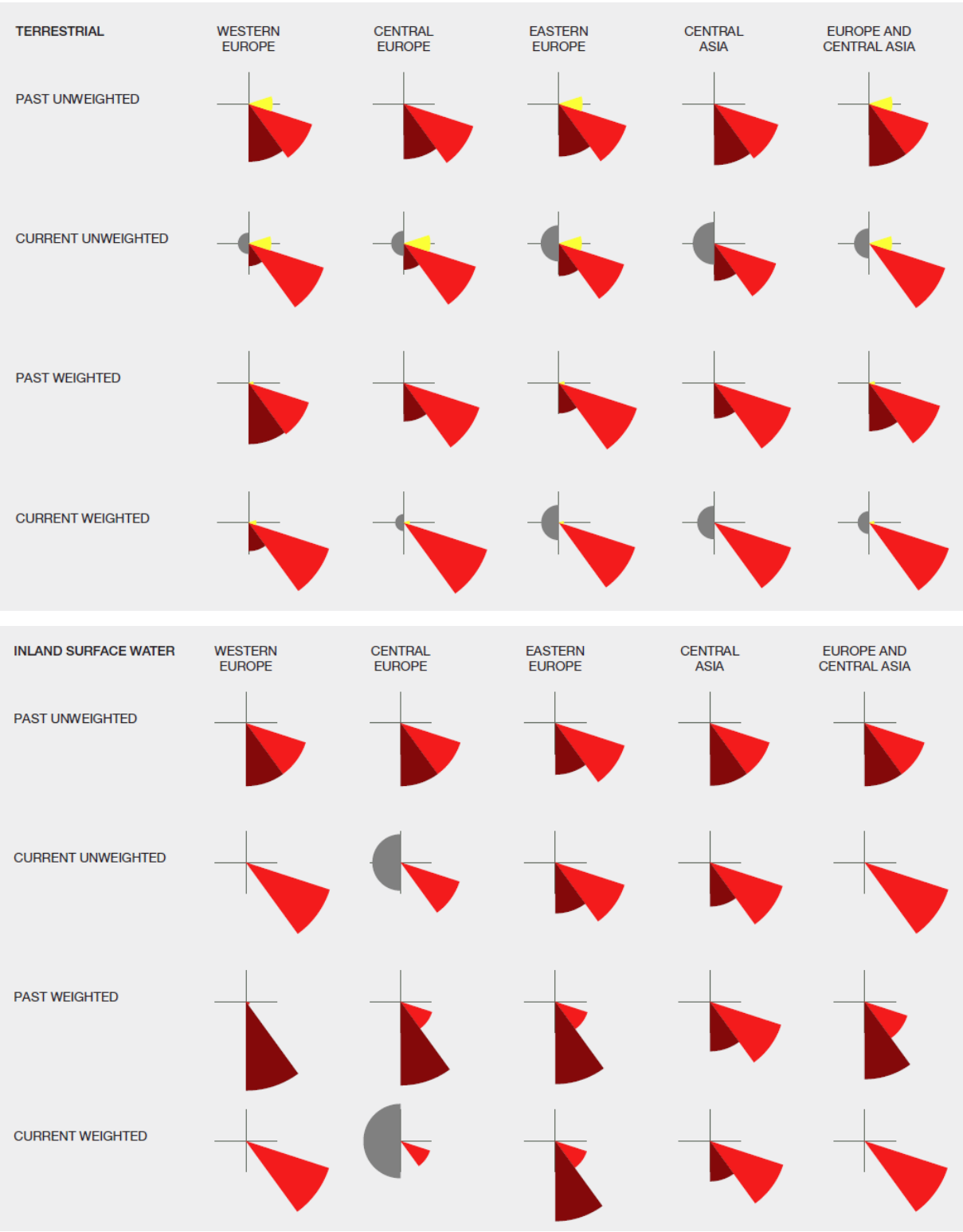
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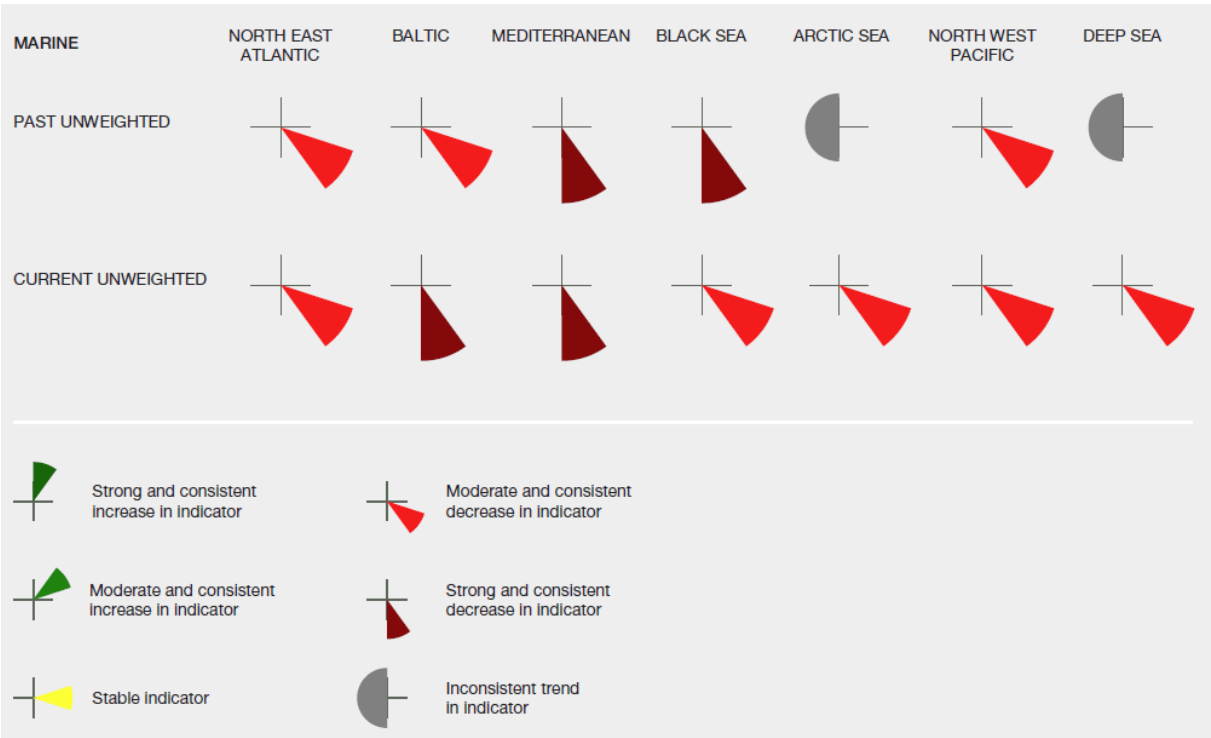
TRENDS AND IMPACTS		Legend <div><div></div> high impact</div> <div><div></div> moderate impact</div> <div><div></div> no or marginal impact</div>																																			
Unit of Analysis	Indicator	General trend						Climate change						Land use change						Pollution						Overexploitation						IAS					
		past			current			past			current			past			current			past			current			past			current								
		ECA	EE	CA	ECA	EE	CA	ECA	EE	CA	ECA	EE	CA	ECA	EE	CA	ECA	EE	CA	ECA	EE	CA	ECA	EE	CA	ECA	EE	CA	ECA	EE	CA						
Terrestrial																																					
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Snow and ice-dominated systems	Extent	↘	↘	↘	↘	↘	↘																														
Snow and ice-dominated systems	Biodiversity status	↘			↘																																
Snow and ice-dominated systems	Biodiversity status	↘	↘	↘	↘	↘	↘																														
Tundra	Extent	↕			↕																																
Tundra	Extent	↕ -		↕ -	↕ -	↕ -																															
Tundra	Biodiversity status	↘			↘																																
Tundra	Biodiversity status	↘ -		↘ -	↘ -																																
Alpine and subalpine systems	Extent	↓			↓																																
Alpine and subalpine systems	Extent	↓	↓	↓	↓	↓	↓																														
Alpine and subalpine systems	Biodiversity status	↓			↓																																
Alpine and subalpine systems	Biodiversity status	↓	↓	↓	↓	↓	↓																														
Temperate and boreal forests and woodland	Extent	↘			↗																																
Temperate and boreal forests and woodland	Extent	↘	↘	↘	↗	↗	↗																														
Temperate and boreal forests and woodland	Biodiversity status	↘			↘																																
Temperate and boreal forests and woodland	Biodiversity status	↘	↘	↘	↘	↘	↘																														
Mediterranean forests, woodland and scrub	Extent	↓			↓																																
Mediterranean forests, woodland and scrub	Extent	↓	↓	↓	↓	↓	↓																														
Mediterranean forests, woodland and scrub	Biodiversity status	↘			↘																																
Mediterranean forests, woodland and scrub	Biodiversity status	↘	↘	↘	↘	↘	↘																														
Tropical and subtropical dry and humid forests	Extent	↓			↕																																
Tropical and subtropical dry and humid forests	Extent	↓	↓	↓	↕	↕	↕																														
Tropical and subtropical dry and humid forests	Biodiversity status	↓			↕																																
Tropical and subtropical dry and humid forests	Biodiversity status	↓	↓	↓	↕	↕	↕																														
Temperate grasslands	Extent	↓			↕																																
Temperate grasslands	Extent	↓	↓	↓	↘	↘	↗																														
Temperate grasslands	Biodiversity status	↓			↕																																
Temperate grasslands	Biodiversity status	↓	↓	↓	↘	↗	↗																														
Deserts	Extent	↗			↗																																
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Deserts	Biodiversity status	↘			↘																																
Deserts	Biodiversity status	↘ -		↘	↘ -																																
Permafrost peatlands	Extent	↔			↔																																
Permafrost peatlands	Extent	↔ -		↔ -	↔ -	↔ -																															
Permafrost peatlands	Biodiversity status	↔			↘																																
Permafrost peatlands	Biodiversity status	↔ -		↔ -	↘ -	↘ -																															
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Boreal peatlands	Extent	↓ -		↓ -	↘ -	↘ -																															
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Boreal peatlands	Biodiversity status	↓ -		↓ -	↘ -	↘ -																															
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TRENDS AND IMPACTS		Legend <div><div>●</div> high impact</div> <div><div>●</div> moderate impact</div> <div><div>●</div> no or marginal impact</div>																																			
		General trend						Climate change						Land use change						Pollution						Overexploitation						IAS					
		past			current			past			current			past			current			past			current			past			current			past			current		
		ECA			EEA			ECA			EEA			ECA			EEA			ECA			EEA			ECA			EEA			ECA			EEA		
Unit of Analysis	Indicator	WE	CE	EE	CA	WE	CE	EE	CA	WE	CE	EE	CA	WE	CE	EE	CA	WE	CE	EE	CA	WE	CE	EE	CA	WE	CE	EE	CA	WE	CE	EE	CA				
Forest-steppe, steppe and other southern pi	Extent	↓				↓				●				●				●				●				●				●							
Forest-steppe, steppe and other southern pi	Extent	↓	↓	↓	↓	↓	↓	↓	↓	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●				
Forest-steppe, steppe and other southern pi	Biodiversity status	↓				↓				●				●				●				●				●				●							
Forest-steppe, steppe and other southern pi	Biodiversity status	↓	↓	↓	↓	↓	↓	↓	↓	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●				
Agricultural areas	Extent	↗				↔								●																							
Agricultural areas	Extent	↔	↗	↑	↑	↔	↗	↓	↓	●	●	●	●	●	●	●	●	●	●	●	●																
Agricultural areas	Biodiversity status	↓				↓				●				●				●												●							
Agricultural areas	Biodiversity status	↓	↓	↓	↓	↓	↓	↓	↓	●	●	●	●	●	●	●	●	●	●	●	●									●	●	●	●				
Urban areas	Extent	↓				↓				●				●				●				●				●				●							
Urban areas	Extent	↓	↓	↓	↓	↓	↓	↓	↓	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●				
Urban areas	Biodiversity status	↓				↓				●				●				●				●				●				●							
Urban areas	Biodiversity status	↓	↓	↓	↓	↓	↓	↓	↓	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●				
Subterranean habitats	Extent	↓				↓				●				●				●				●				●				●							
Subterranean habitats	Extent	↓	↓	↓	↓	↓	↓	↓	↓	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●				
Subterranean habitats	Biodiversity status	↓				↓				●				●				●				●				●				●							
Subterranean habitats	Biodiversity status	↓	↓	↓	↓	↓	↓	↓	↓	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●				
Inland surface water																																					
Freshwater	Extent	↓				↓				●				●				●				●				●				●							
Freshwater	Extent	↓	↓	↓	↓	↓	↓	↓	↓	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●				
Freshwater	Biodiversity status	↓				↓				●				●				●				●				●				●							
Freshwater	Biodiversity status	↓	↓	↓	↓	↓	↓	↓	↓	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●				
Aral Sea	Extent	↓				↓				●				●				●				●				●				●							
Aral Sea	Extent	-	-	-	↓	-	-	-	↓	-	-	-	●	-	-	-	●	-	-	-	●	-	-	-	●	-	-	-	●	-	-	-	●				
Aral Sea	Biodiversity status	↓				↓				●				●				●				●				●				●							
Aral Sea	Biodiversity status	-	-	-	↓	-	-	-	↓	-	-	-	●	-	-	-	●	-	-	-	●	-	-	-	●	-	-	-	●	-	-	-	●				
Caspian Sea	Extent	↕				↔				●				●				●				●				●				●							
Caspian Sea	Extent	-	-	↓	↓	-	-	↔	↔	-	-	●	●	-	-	●	●	-	-	●	●	-	-	●	●	-	-	●	●	-	-	●	●				
Caspian Sea	Biodiversity status	↓				↓				●				●				●				●				●				●							
Caspian Sea	Biodiversity status	-	-	↓	↓	-	-	↓	↓	-	-	●	●	-	-	●	●	-	-	●	●	-	-	●	●	-	-	●	●	-	-	●	●				
Saline lakes	Extent	↓				↓				●				●				●				●				●				●							
Saline lakes	Extent	↓	↓	↓	↓	↓	↓	↓	↓	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●				
Saline lakes	Biodiversity status	↓				↓				●				●				●				●				●				●							
Saline lakes	Biodiversity status	↓	↓	↓	↓	↓	↓	↓	↓	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●				
Marine																																					
Northeast Atlantic	Biodiversity status	↓				↓				●				●				●				●				●				●							
Baltic Sea	Biodiversity status	↓				↓				●				●				●				●				●				●							
Mediterranean Sea	Biodiversity status	↓				↓				●				●				●				●				●				●							
Black and Azov Seas	Biodiversity status	↓				↓				●				●				●				●				●				●							
Arctic Ocean	Biodiversity status	↕				↓				●				●				●				●				●				●							
Northwest Pacific Ocean	Biodiversity status	↓				↓				●				●				●				●				●				●							
ECA deep-sea	Biodiversity status	↕				↓				●				●				●				●				●				-			-				

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11091

Figure 3.43: Summary graphs of past and current trends in biodiversity and ecosystems in terms of biodiversity status for terrestrial and inland surface water units of analysis and marine systems. These graphs are based on Table 3.5, with “weighted” denoting graphs for which the units of analysis or systems were weighted by their area, and “unweighted” denoting graphs not weighted by area.





End of Box 3.3.

3.4 Past and current trends by taxonomic group

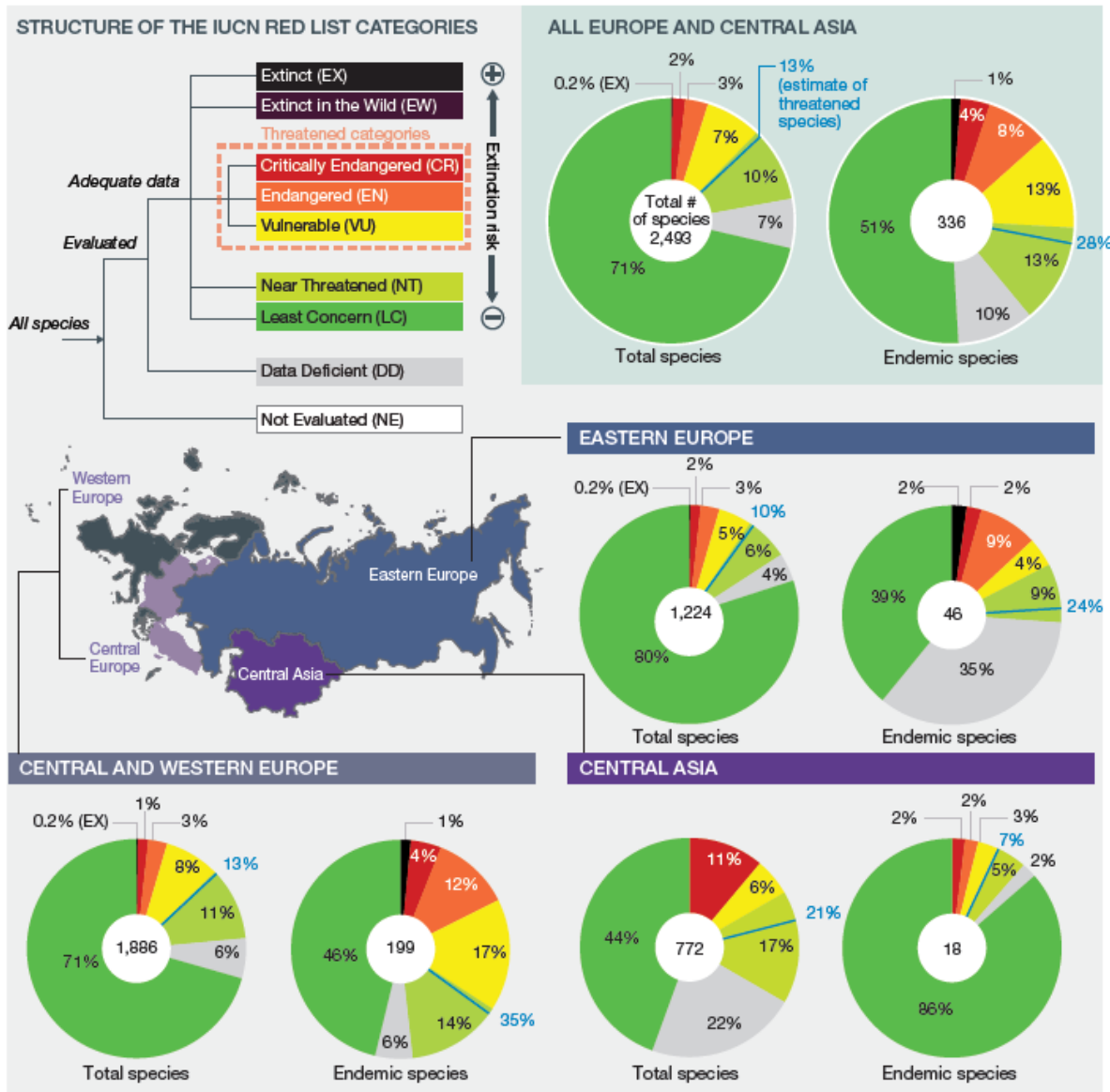
3.4.1 Introduction

Europe and Central Asia hosts more than 10% of the world’s vascular plant species, and about 25% of animal and plant groups comprehensively assessed by IUCN are unique to this region. Between 20 and 120 species have gone extinct regionally and an additional 44 to 67 have gone extinct globally since the 1500s²⁶ (data summarized from the IUCN Red List of Threatened Species - Species Information System, March 2017). These numbers are an under-estimation considering that only about 86,000 species have been assessed by the IUCN, less than 4% of species of plants and animals described today (estimated to be 2.3 millions according to Jenkins, Pimm, & Joppa (2013). In addition to the extinctions recorded at large scale, numerous extinction events were recorded at the country level. The following statistics are based on a subset of taxonomic group that has been comprehensively assessed.²⁷ A high risk of extinction faces 13.0% of species occurring in Europe and Central Asia in these selected groups and for which data is available (94% of the 2,493 species in these taxonomic groups). 13.5% of the species in the region are endemic, and 27.9% of these species are threatened. The Central and Western European subregions hold the highest percentages of species threatened (13.3%) and endemic (10.6%), and the highest percentage of endemics threatened (35.1%), with these percentages primarily

²⁶ The lower value are the documented number of extinctions, the upper value is obtained by including also all species classified by IUCN as possibly extinct.

²⁷ Mammals, birds, chameleons, amphibians, sharks and rays, selected bony fish groups (angelfishes and butterflyfishes, tarpons and ladyfishes, parrotfishes and surgeonfishes, groupers, wrasses, tunas and billfishes, hagfishes, sturgeon, blennies, pufferfishes, seabreams, porgies, picarels), freshwater caridean shrimps, cone snails, freshwater crabs, freshwater crayfish, lobsters, reef-building corals, conifers, seagrasses, and plant species occurring in mangrove ecosystems. Species assessed by IUCN in other taxonomic groups may not be a random sample, but likely a subset of species deemed at higher risk of extinction, therefore extrapolating their extinction risk to all species may bias the percentage of species endangered.

11117 driven by the many threatened endemic species in the Mediterranean hotspot and the Macaronesian
11118 Islands (Figure 3.44).



11119
11120 **Figure 3.44: Overview of extinction risk of species in the Europe and Central Asia region (IUCN,**
11121 **2017c).**

11122 Eastern Europe and Central Asia have lower percentages of species threatened (<10%) and endemic
11123 (<5%), and a smaller proportion of endemics threatened (<10%). For mammals, birds, and amphibians,
11124 global assessments of extinction risk against the Red List Categories and Criteria have been undertaken
11125 multiple times over the last three decades to derive Red List Indices as indicators of the rate at which
11126 species groups are sliding towards extinction, and these can be combined with species distribution
11127 data to produce geographically downscaled Red List Indices (i.e., regional contributions towards the
11128 global Red List Index; Rodrigues et al. 2014). Specifically, changes in aggregate extinction risk of all
11129 regions' and subregions' species can be calculated, showing how adequately species are conserved
11130 relative to their potential contribution to global species conservation. The contribution to increasing
11131 global extinction risk varies among the subregions, with Central and Western Europe contributing the
11132 most, followed by Central Asia and Eastern Europe (Figure 3.45).

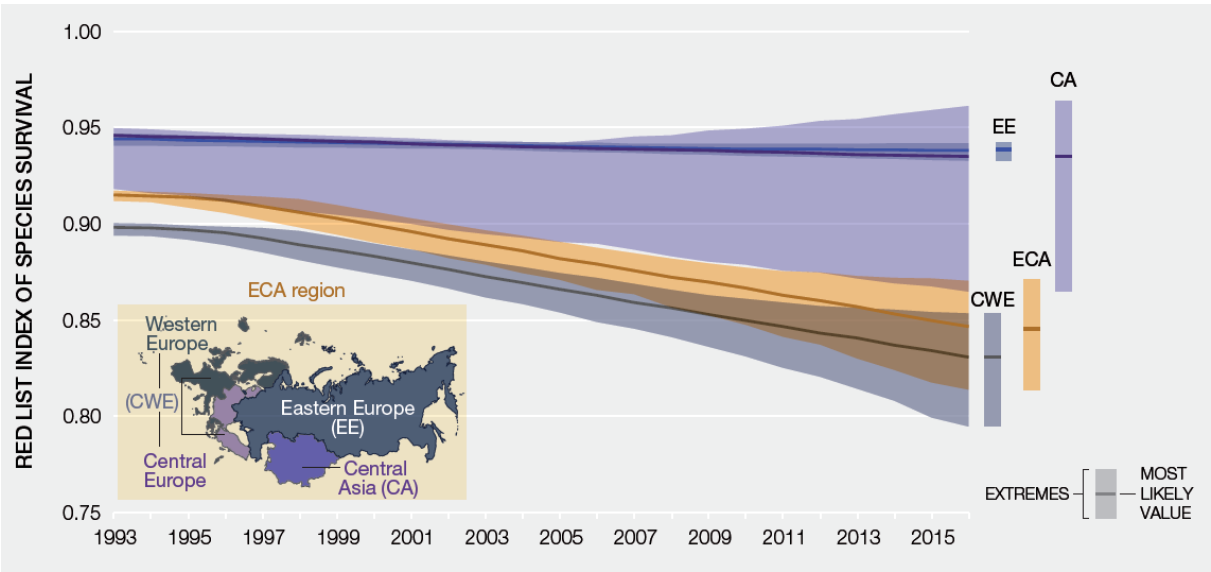


Figure 3.45: Red List Indices of species extinction risk weighted by the fraction of each species’ distribution occurring within Europe and Central Asia and its subregions. The position on the y-axis indicates the aggregate extinction risk facing species in the region overall, while the slope indicates how rapidly this extinction risk is changing. For the region as a whole, the risk of extinction of species has increased over the last 20 years. Species in the Central and Western Europe subregions are least well-conserved relative to the region’s potential contribution to global species conservation, and are declining fastest in status. Data from Brooks et al (2016).

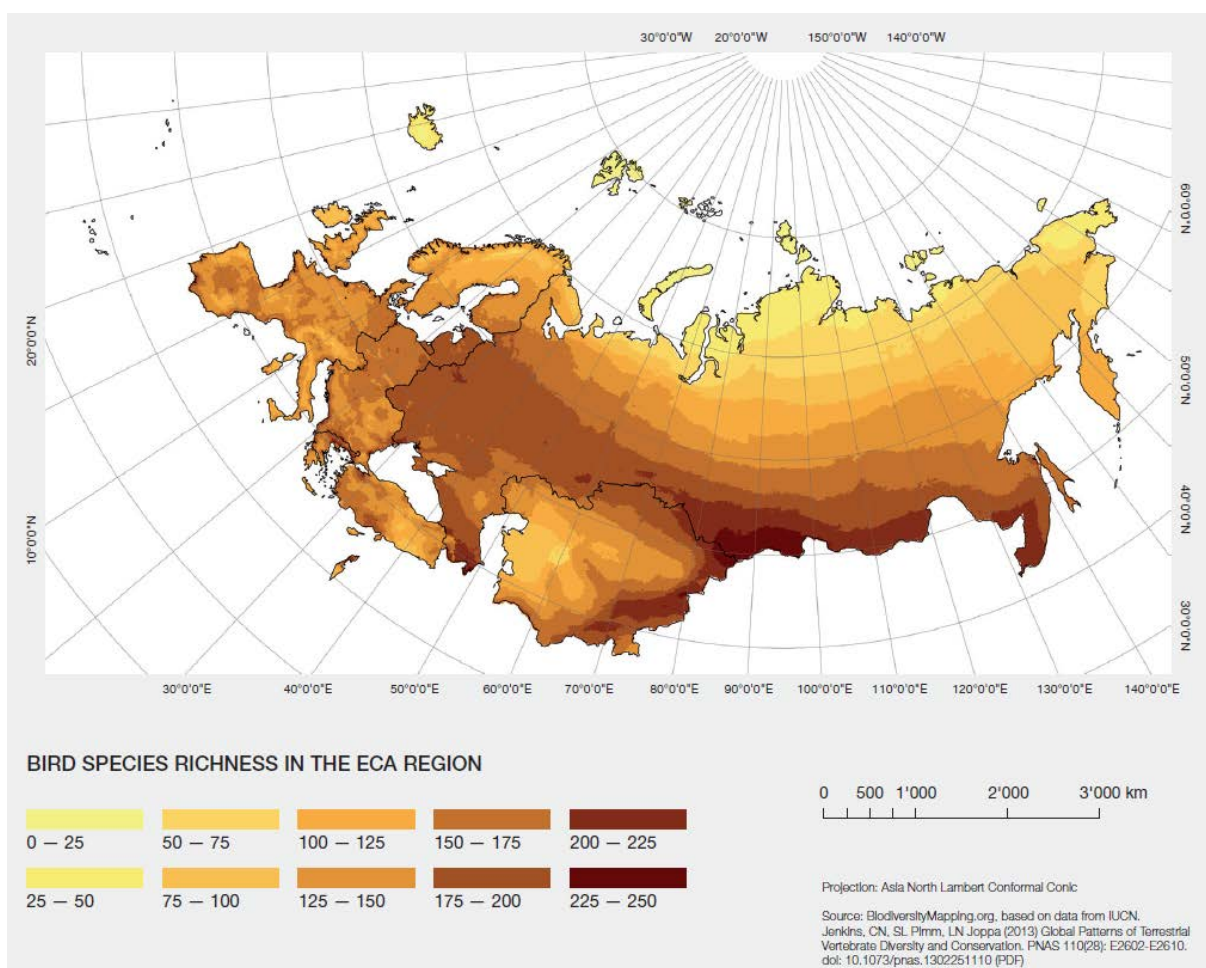
Below we discuss status and trends for most major taxonomic groups. These trends and their attribution to different direct drivers are summarized in **Table 3.11**. Insufficient data were available to assess status and trends of marine species except for mammals, birds and fishes. Status and trends in community composition and biomass stocks of marine plankton are dealt with in the marine units of analyses section, whereas the lack of status and trends of other taxonomic groups, including non-planktonic marine invertebrates, algae and protozoans, are discussed in the knowledge gaps section.

3.4.2 Birds

Status and trends

There are an estimated 887 extant bird species in Europe and Central Asia, 25 endemic (BirdLife International, 2016), and 71 threatened with extinction (categories Vulnerable, Endangered and Critically Endangered; BirdLife International 2016). Analysis of changes of categories in the IUCN Red List between 1988 and 2008 suggests that Eastern Europe was the subregion with the greatest declines (the most changes towards higher threat categories), and Central Asia was the subregion with the smallest declines (Brooks et al., 2016b). No species within the region has gone extinct since 1980, but three species are possibly extinct or nearing extinction in the Western, Central and Eastern European subregions (BirdLife International, 2016).

Areas of high bird richness include Russia, Turkey, the Mediterranean, Israel, the Black Sea and the Caucasus (BirdLife International, 2015, 2016; **Figure 3.46 A**). The highest rates of endemism, and highest numbers of threatened species (Jenkins et al. 2013, BirdLife International 2016; **Figure 3.46 B**) are found in the Mediterranean and Macaronesian islands, as well as the Caucasus (BirdLife International, 2015a, 2016), and Central Asia.



11163

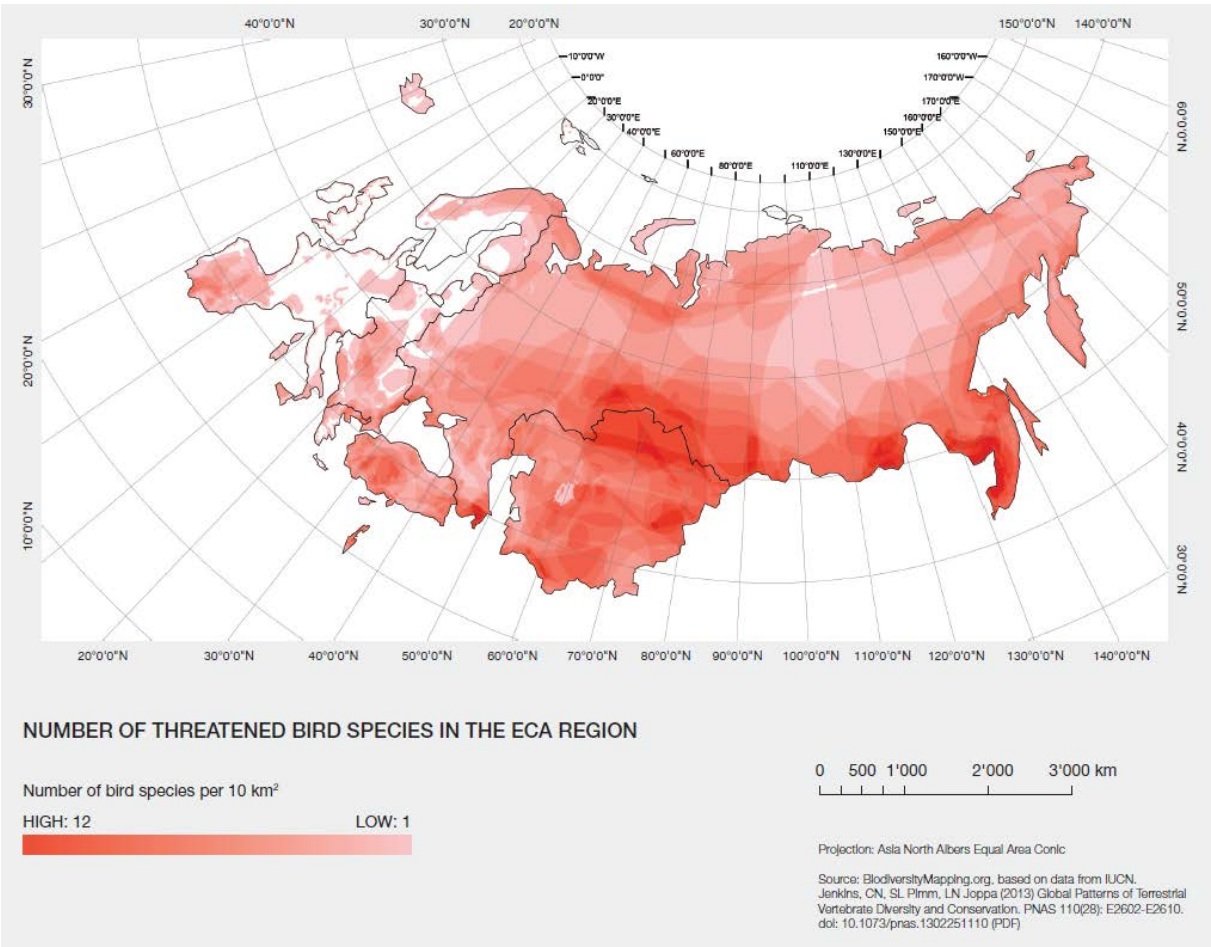


Figure 3.46: Top: Bird species richness in Europe and Central Asia. Note low resolution of data for eastern parts of the region due to lack of sources. Bottom: Number of threatened species of birds in Europe and Central Asia. Adapted from: Jenkins et al. (2013), BirdLife International (2016). 10km resolution, Lambert Conformal Conic projection.

There is strong evidence for a moderate *overall decline of bird populations* in the region (BirdLife International, 2017). A recent report (BirdLife International, 2015) shows that out of the 533 species breeding in the EU-27 countries, 153 have declined since 2001, while 136 show a long-term decline (since 1980, **Table 3.6**). Most of the large-scale, long-term research studies (Gregory et al., 2007; Jørgensen et al., 2016; Reif, Voříšek, Šťastný, Bejček, & Petr, 2008; Vickery et al., 2014) as well as many smaller studies (e.g. Vilkov 2013) also report declines in either species richness or populations. However, different species groups and regions exhibit different trends, and knowledge gaps exist. Notably, population sizes are unknown for many species, particularly in Eastern Europe and Central Asia (BirdLife International, 2017).

Table 3.6: Long-term and recent trends of bird species breeding in EU-27 countries (EEA, 2015). Short-term covers the time period 2001-2012, and long-term the period 1980-2012. The total number of species is 456.

Trend	Long-term	Short-term
Declining	136	153
Increasing	150	133
Stable	49	96
Fluctuating	6	12
Uncertain	55	23

Unknown	79	58
---------	----	----

11181
11182 A large proportion of species in decline are associated with marine habitats (BirdLife International,
11183 2015a). Terrestrial species show contrasting trends among functional groups. Decline is strongest for
11184 migratory birds (BirdLife International, 2008; Vickery et al. 2014) and habitat specialists (Le Viol et al.,
11185 2012). The latter, coinciding with an increased frequency of generalist species, leads to a decrease in
11186 functional diversity. This trend, often referred to as “biotic homogenization”, is maybe the typical
11187 change in terrestrial avian communities across groups and locations (Le Viol et al., 2012).

11188 *Genetic diversity* is often studied at the population level (Eeva, Belskii, & Kuranov, 2006; Liu et al.,
11189 2013) and no clear large-scale trend patterns have been detected as this is still a young field of
11190 exploration. Possible threats to avian genetic diversity include habitat fragmentation, hybridization
11191 with feral (Randi, 2008) or introduced or invasive species (Muñoz-Fuentes, Vilà, Green, Negro, &
11192 Sorenson, 2007).

11193 11194 ***Drivers of change***

11195 Exploitation (hunting, poaching, and bycatch from fisheries) was found to be the largest threat to
11196 Vulnerable or Endangered species by the IUCN (BirdLife International, 2015a). Although the exact
11197 numbers of birds killed are difficult to evaluate due to lack of data, the order of magnitude in the entire
11198 Mediterranean region is several millions of birds killed each year (Arizaga & Laso, 2015; Brochet et al.,
11199 2016; Casas, Mougeot, Urruzuola, & Bretagnolle, 2009; Sokos, Birtsas, Connelly, & Papaspyropoulos,
11200 2013), while hunting and poaching seem also to be significant in Central Asia (BirdLife International,
11201 2016; Chemonics International, 2001a).

11202 Land and water use is an important driver as it affects multiple species at once. As such it is often
11203 reported both in scientific literature and indigenous and local knowledge sources (Roué and Molnár
11204 2016). Overall, decreases in the extent of specific habitats and urban expansion contribute to biotic
11205 homogenization (Le Viol et al., 2012; McKinney, 2006). Recent agricultural changes have had a
11206 dramatic effect on bird diversity (Donald et al. 2001, also see section on Agricultural areas). Amongst
11207 forest birds, several changes have been documented, mostly showing a decrease in old forest
11208 specialists, deciduous forest specialists, and cavity-nesters. All these changes can be related to the
11209 intensification of forestry practices, which often entail dense monocultures that are harvested before
11210 structural elements can benefit many bird species (Gil-Tena, Saura, & Brotons, 2007; Löhmus, Nellis,
11211 Pullerits, & Leivits, 2016; Sirkiä et al., 2010; Smith et al., 2008). However, no large-scale consensus on
11212 land use related trends in forest birds seems to exist (Gregory et al., 2007; Ram, Axelsson, Green,
11213 Smith, & Lindström, 2017).

11214 There is clear evidence that bird communities are locally affected by pollution from industrial activities
11215 (Eeva, Belskii, Gilyazov, & Kozlov, 2012) or pesticide use in agricultural fields, directly (Wegner,
11216 Kleinstäuber, Baum, & Schilling, 2005) or indirectly (Hallmann et al., 2014). Light pollution in urban
11217 environments has been shown to affect the timing of reproductive events (Dominoni & Partecke,
11218 2015), but there is not yet any clear evidence of an impact on abundance or community composition.

11219 Invasive alien species and invasive native species (e.g. rats, domestic cats), have been shown to
11220 threaten the reproductive success of many birds, particularly colonial seabirds (BirdLife International,
11221 2015a), and have been linked with declines of some species (e.g. Skorka, Lenda, & Tryjanowski, 2010).

11222 Climate-driven community changes and range expansions or contractions have been reported in many
11223 studies (Estrada, Morales-Castilla, Caplat, & Early, 2016), and both scientific studies and reports from
11224 indigenous herders suggest that local bird declines have been caused by climate change (Roué &

11225 Molnár, 2016; Vilkov, 2013). However, evidence of direct impacts of climate change on population
11226 decline remains weak.

11227 Other important drivers include direct mortality caused by power lines and wind turbines, although
11228 the consequences of population decline are only documented for a few, rare species (BirdLife
11229 International, 2015a).

11230 In many cases, it is the combination of drivers that put bird species at risk. Seabirds, for instance, have
11231 declined strongly due to a multiplicity of threats. Conservation efforts reducing multiple pressures (e.g.
11232 the European Union habitat directive, national legislations) have been shown to have positive effects
11233 on bird populations (Gamero, 2016).

11234

11235 3.4.3 Mammals

11236 **Status and trends**

11237 There are 538 species of mammals in the IUCN database that are extant in the region. Of these, 66 are
11238 threatened with extinction (categories Vulnerable, Endangered and Critically Endangered). Their
11239 number could be up to 124 (23% of the total) if all Data Deficient species were found to be Vulnerable
11240 or worse (IUCN, 2016). Globally, the net annual change in IUCN extinction risk categories for mammals
11241 from 1996 to 2008 has been -13, meaning that, on average, 13 species moved one category closer to
11242 extinction (Brooks et al., 2016b). The Europe and Central Asia contribution to the global trend is -0.47,
11243 which is equivalent to having one species endemic to the region moving one category closer to
11244 extinction every two years (Brooks et al., 2016b).

11245 A notable decline in Europe and Central Asia in recent decades is that of the *Saiga tatarica*, an antelope
11246 inhabiting the steppes and semi-desert regions in Russia, Kazakhstan, Uzbekistan and Western
11247 Mongolia, which deteriorated from Vulnerable in 1996 to Critically Endangered in 2008. This followed
11248 a greater than 95% decline in population size from approximately one million in the early 1990s to an
11249 estimated 50,000 by 2008, primarily owing to poaching. An epidemic of pasteurellosis in 2015 caused
11250 a further population collapse by 50% in two weeks, with an estimated mortality of >70% (Milner-
11251 Gulland & Singh, 2016).

11252 However, species that have received conservation attention are generally improving their
11253 conservation status. There are 87 mammal species in the Annex II, IV and V of the European Union
11254 Habitat Directive. European Union member States are required to take steps towards their
11255 conservation report on the conservation status of these species every six years. Species in these
11256 annexes generally improved their conservation status between 2006 and 2012 relative to the previous
11257 six years (**Table 3.7**). Mammal species had more populations with stable or genuinely improved
11258 conservation status than otherwise in all biogeographic areas in the European Union except Boreal,
11259 and Marine Mediterranean (EEA, 2015).

11260 **Table 3.7 Number of mammal species in each biogeographic area of European Union countries**
11261 **whose conservation status was stable, or genuinely improved or worsened between the 2001-2006**
11262 **assessment period and the 2007-2012 period. Total indicates the total number of species or**
11263 **biogeographic region assessments of mammals in the European Union and include also assessments**
11264 **with non-genuine changes (e.g. because of taxonomic revisions or improved knowledge), or**
11265 **unknown or unreported trends. The biogeographic areas are Alpine (ALP); Atlantic (ATL); Boreal**
11266 **(BOR); Continental (CON); Macaronesian (MAC); Mediterranean (MED); Pannonian (PAN), Marine**
11267 **Mediterranean (MMED), Marine Atlantic (MATL), Marine Baltic (MBAL). No genuine changes were**
11268 **recorded for the Macaronesian and Marine Macaronesian regions and are not reported here. Species**

11269 of the Black Sea and Steppic region were only assessed in 2012 and are excluded here. Species with
 11270 non-genuine changes in assessment, are not reported here.

	ALP	ATL	BOR	CON	MAC	MED	PAN	MATL	MBAL	MMED
Stable	9	11	3	27	3	11	13	3	2	1
Improved	8	17	1	15	3	5	1	2	3	0
Worsened	14	15	5	22	1	5	13	1	1	1
Total	364	213	111	416	14	222	119	156	22	75

11271
 11272 Remarkable recoveries due to conservation efforts include the one of the European bison, *Bison*
 11273 *bonasus*, which was extinct in the wild after World War I and reduced to a captive population of 54
 11274 animals. Conservation efforts started in 1929 with a captive breeding programme followed by
 11275 reintroductions in Białowieża National Park in Poland; Russia and several other locations in Europe.
 11276 Today there are more than 2,700 wild bison, in several populations, mostly stable or increasing in
 11277 numbers. Other remarkable recoveries are that of the European beaver (*Castor fiber*), the European
 11278 hamster (*Cricetus cricetus*) (EEA, 2015) and large terrestrial carnivores (Chapron et al., 2014). Among
 11279 the latter group, are once Critically Endangered large felids such as the Iberian lynx (*Lynx pardinus*)
 11280 whose population tripled from 2002 (52 mature individuals) to 2012 (156), the Amur tiger (*Panthera*
 11281 *tigris altaica*), from 20-30 animals in the 1930s to 500 and stable in 2016, and the Amur leopard
 11282 (*Panthera pardus orientalis*), whose population has doubled since 2000. Among marine mammals, the
 11283 Baltic seal (*Pusa hispida ssp. botnica*) rebounded from 3,000 individuals in the 1970s affected by
 11284 hunting pressure and impaired fertility due to organochlorine pollution, to over 25,000 today thanks
 11285 to hunting regulations afforded by the European Union and national legislations, habitat protection
 11286 and improved water quality (Härkönen, 2015).

11287 11288 **Drivers of change**

11289 National and international legislation affording legal protection and law enforcement are the main
 11290 drivers of large carnivore recoveries in Western and Central Europe (Chapron et al., 2014). Habitat
 11291 protection and law-enforcement by government and non-government agencies are the main drivers
 11292 in Eastern Europe (Ministry of Natural Resources and Environment of the Russian Federation, 2015).

11293 The main threats to terrestrial mammal species in the region are land-use change (including changes
 11294 to intense cropland and pastures, logging, and extractive activities), affecting 186 species; followed by
 11295 hunting and trapping, affecting 123 species; and invasive species, affecting 73 species; it should be
 11296 noted that these threats are not mutually exclusive (Joppa et al., 2016). Nearly all marine mammals
 11297 are impacted by persistent organic pollutants, especially polychlorinated biphenyls (PCBs), despite
 11298 being banned by the Stockholm Convention in 2004, their concentrations in sediments and in the
 11299 marine food-chains have remained high, due to low compliance to the Convention requirements of
 11300 safe storage and elimination of PCB stockpile and limited decontamination of sediments, landfills,
 11301 building and equipment (Stuart-Smith & Jepson, 2017). As a result, high PCB concentrations in
 11302 European cetaceans from 1990 to 2012 were associated with long-term population declines and low
 11303 or zero rates of reproduction, consistent with severe PCB-induced population-level effect (Jepson et
 11304 al., 2016). Climate change is an emergent threat for mammals that is potentially overlooked in the
 11305 region (Pacifi et al., 2015 **Table 3.11**).

11306

3.4.4 Reptiles

Status and trends

Reptile species richness across the region follows a latitudinal gradient. It is highest in southern Turkey and along the eastern Mediterranean coast to Israel, with further hotspots in parts of the Iberian peninsula and southern France, the Balkans, southern Transcaucasia, the southern deserts of Central Asia and southern and far east Russia (**Figure 3.47**, Feldman et al., 2014). At the subregional level, species richness is highest across Western Europe, with 213 species recorded and 212 assessed (**Table 3.8**). This is due to the subregion combining separate faunas: the Macaronesian fauna of Portugal and Spain, the western Mediterranean fauna and the fauna of the eastern Mediterranean of Israel.

Species richness of small-range endemics is highest in the Caucasus, southern Balkan Peninsula, central and southern Iberian Peninsula, southern Turkey, and southern Central Asia. There are also a number of important refugia, i.e. places supporting a relict population of a previously more widespread species. These are both mesophyllic (Caucasian Black Sea coast of Russia, Georgia, Turkey & Southeast Azerbaijan & southern Far East Russia (Tuniyev, 1990, 1997)) and xerophyllic (Spain, Portugal, Italy, Greece, Turkey, Armenia, Azerbaijan, Georgia, Russia and Central Asia (Tuniyev, 1995)).

Areas of high diversity at the level of genera and families are: the Balkan Peninsula for turtles; south Turkey and Kopet Dag for skinks; Central Asia for agamas; south Mediterranean and southern Central Asia for geckos; the Caucasus, southern Balkan Peninsula and Iberian Peninsula, Mediterranean and Aegean Sea islands for lacertids; southern Central Asia for boas; and the Caucasus and north-east Turkey for vipers.

In this assessment we compiled a dataset of all 408 extant species of reptiles occurring in Europe and Central Asia from the Reptile Database (Uetz, 2017) and IUCN Red List of Threatened Species (IUCN, 2017c). Of these, 289 have published assessments of extinction risk on the IUCN Red List. Sixty-three species are assessed as threatened with extinction (categories Vulnerable, Endangered and Critically Endangered; **Table 3.8**). Thus between 21.7% (assuming that no Data Deficient species are threatened with extinction) and 26.6% (assuming that all Data Deficient species are threatened with extinction) of species within the region are threatened with extinction. Best estimates of extinction threat generally assume that Data Deficient species fall into non-Data Deficient categories in the same proportions as non-Data Deficient species (IUCN, 2017a), indicating here that about 22.8% of reptile species in Europe and Central Asia are threatened with extinction. This level of threat is similar to the one of reptiles globally (18.8% (Böhm, Collen, Baillie, & Bowles, 2013)) and across Europe (Western, Central and Eastern Europe, including the Russian Federation up to the Urals and excluding the Caucasus) (19.7% (Cox & Temple, 2009); $\chi^2=2.31$, $df=2$, $p=0.315$). However, recent studies suggest that globally Data Deficient reptiles are neither widespread nor common, suggesting there may be an underestimation of extinction risk (Meiri et al., 2017).

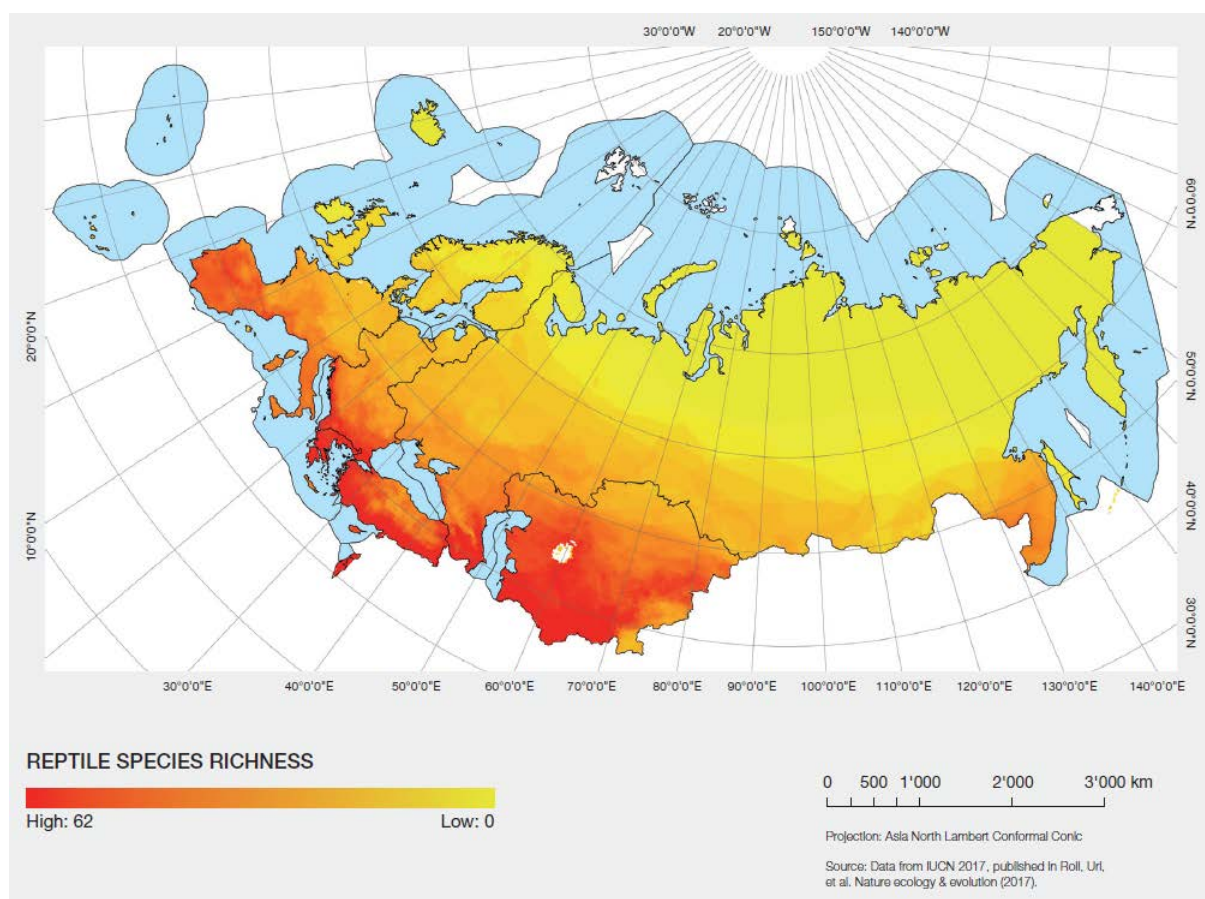


Figure 3.47: Species richness of reptiles across Europe and Central Asia.

Table 3.8 Global IUCN Red List status of reptiles occurring within the Europe and Central Asia assessment region, for species with a published assessment (Total = 289). N is the number of species recorded in the assessment region. IUCN categories: DD: Data deficient; LC: Least concern; NT: Near threatened; VU: Vulnerable; EN: Endangered; CR: Critically endangered (IUCN, 2017c).

Group	DD	LC	NT	VU	EN	CR	Total	N	% threatened	% lower bound	% upper bound
Reptiles	14	186	26	21	25	17 ¹	289	408	22.9	21.8	26.6
Lizards	6	120	17	13	16	12 ¹	184	246	23.0	22.3	25.5
Snakes	7	63	7	4	7	4	92	141	17.7	16.3	24.0
Amphisbaenians	0	2	0	0	0	0	2	5	-	-	-
Turtles/tortoises	1	1	2	4	2	1	11	16	70.0	63.6	72.7
By region											
Western Europe	3	105	18	11	14	9 ¹	160	212	21.7	21.3	23.1
Central Europe	4	88	11	6	9	5	123	156	16.8	16.3	19.5
Eastern Europe	2	55	9	6	4	2	78	119	15.8	15.4	18.0
Central Asia	5	51	1	4	2	3	66	109	14.5	13.4	20.9
Endemics											
Endemic ECA	7	52	17	11	17	14 ¹	118	145	37.8	35.6	41.5
Western Europe ²	2	25	11	4	8	6 ¹	56	71	33.3	32.1	35.7
Central Europe ^{2,3}	3	16	5	2	6	4	36	45	36.4	33.3	41.7
Eastern Europe ^{3,4}	0	11	5	3	4	2	25	28	36.0	36.0	36.0
Central Asia ⁴	3	9	0	3	1	3	18	21	46.7	38.9	55.6

¹ *Gallotia avaritae*, endemic to the Canary Islands, is listed as Critically Endangered (Possibly Extinct)

11350 ² Four species endemic to Western Europe and Central Europe

11351 ³ Eleven species endemic to Central and Eastern Europe

11352 ⁴ Two endemic species shared between Eastern Europe and Central Asia

11353

11354 Extinction threat is lowest for snakes and highest for turtles and tortoises (**Table 3.8**) which is
11355 comparable to global patterns (Böhm et al., 2013). Extinction risk across all assessed species is highest
11356 in Western Europe. More than one third of reptiles endemic to Europe and Central Asia subregions are
11357 at risk of extinction and this threat is highest across Central Asia (**Table 3.8**). Not all species have been
11358 assessed yet for the IUCN Red List, however, there are a number of ongoing assessments.

11359 One Canary Island endemic, *Gallotia auaritae*, is listed as Possibly Extinct or likely extinct (Martin, 2009;
11360 Mateo Miras Martínez-Solano, 2009). There is evidence for at least two extinctions from Europe and
11361 Central Asia: the Persian toad agame *Phrynocephalus persicus* is thought to have gone extinct from
11362 Azerbaijan and now solely exists outside Europe and Central Asia in Iran (Anderson Turiyev & Bafti,
11363 2009). In Israel, the Nile crocodile (*Crocodylus niloticus*) was lost in the early 20th century, probably due
11364 to hunting (Dolev Pervolutzki, 2004; Masterman, 1921). Of the more speciose genera, those with most
11365 threatened species include the narrow-endemic vipers (genus *Vipera sensu lato*, 22 species, 45%
11366 threatened, six Not Evaluated), toad-headed agamas of Eastern Europe and Central Asia (genus
11367 *Phrynocephalus*, 13 species, 31% threatened, three Not Evaluated); species of mostly Mediterranean
11368 wall lizards, often very common, but with small ranges (genus *Podarcis*, 23 species, 30% threatened,
11369 three Not Evaluated); and the Caucasian – Asia Minor rock lizards (genus *Darevskia*, 26 species, 23%
11370 threatened, three Not Evaluated).

11371 Compared with data on extinction risk, data on reptile population trends are sparse. Deriving trends
11372 from IUCN Red List data is difficult since not all species have yet been assessed and many have only
11373 ever been assessed once. Only one species has a documented change in global extinction risk, the
11374 globally distributed leatherback sea turtle, *Dermochelys coriacea*, Critically Endangered in 2004 and
11375 Vulnerable in 2013. Of the 289 species with published IUCN Red List assessments, 98 species show
11376 declining populations and only five show an increasing trend across their global range: three Least
11377 Concern species (*Cyrtopodion scabrum*, *Hemidactylus turcicus*, *Podarcis siculus*) and two Critically
11378 Endangered species of the Canary Island endemic *Gallotia* (*Gallotia bravoana*, *G. intermedia*), which
11379 have been subject to conservation action (control of predators). Populations for 119 species are
11380 considered stable, and the status of the remaining 61 is unknown.

11381 The Living Planet database currently contains 66 population time series representing 23 species of
11382 reptiles for Europe and Central Asia (LPI, 2016). These are exclusively from Western and Central Europe
11383 (49 and 17 time series, representing 22 and three species, respectively). Most Central European
11384 population time series focus on marine turtles in Turkey and Cyprus. In Western Europe, data are also
11385 available for snakes and lizards. The loggerhead turtle (*Caretta caretta*) is increasing across available
11386 time series, while the few time series available for *Testudo hermanni* (Not Threatened on the IUCN
11387 Red List), three species of vipers (*Vipera aspis*, Least Concern; *V. berus*, Not Evaluated; *V. ursinii*,
11388 Vulnerable) and *Hierophis viridiflavus* indicate declining population trajectories. Increases in sea turtle
11389 populations have been noted in other parts of the eastern Mediterranean too, for example in Israel
11390 (Casale & Margaritoulis, 2010).

11391 Other data sources suggest declines for *Testudo kleinmanni* in Israel, the only country in Europe and
11392 Central Asia where this species is thought to occur (Dolev Pervolutzki, 2004). There is also direct
11393 evidence from the literature that some snake populations are in decline in specific Western European
11394 localities (e.g., UK: *Coronella austriaca*; Italy: *Vipera aspis*, *Vipera ursinii* ; France: *Vipera aspis*,
11395 *Hierophis viridiflavus*, *Zamenis longissimus*; Reading et al., 2010).

Annexes II, IV and V of the European Union Habitat Directive list 91 reptile species and 7 subspecies. Most species were only assessed once for the European Union Habitat Directive or did not have enough information for a conclusive definition of their status. In many cases it is therefore not possible to determine a trend (**Table 3.9**). Only few genuine changes in conservation status were recorded between the two reporting period. However, only one species and one subspecies were recorded to have a worsening status between the two assessment periods of 2001-2006 and 2007-2012: *Podarcis lilfordi* in the Mediterranean, though in places this species is still very common; and *Lacerta vivipara pannonica*. In terms of spatial planning, however, a recent study suggests that the Natura 2000 network mostly covers widespread reptile species, while narrow-range endemics are under-represented in Natura 2000 and national protected area networks (Abellán Sánchez-Fernández, 2015).

Table 3.9: Number of reptile species in each biogeographic area of European Union countries whose conservation status was stable, or genuinely improved or worsened between the 2001-2006 assessment period and the 2007-2012 period. Acronyms as in Table 3.7. Species of the Black Sea and Steppic area were only assessed in 2012 and are excluded here. Non-genuine changes were mainly due to taxonomic revisions or improved knowledge.

	ALP	ATL	BOR	CON	MED	PAN	MATL	MME D
Stable	2	4	1	10	4	5	0	2
Improved	2	2	0	0	0	1	0	1
Worsened	5	2	3	0	1	2	0	1
Non-genuine changes /Unknown/Not Assessed	86	34	10	112	128	34	22	22

Drivers of change

The main threats to reptiles in Europe and Central Asia, according to the IUCN Red List, are agriculture, residential/commercial development, and biological resource use (**Figure 3.48**). These threats primarily cause habitat fragmentation and loss.

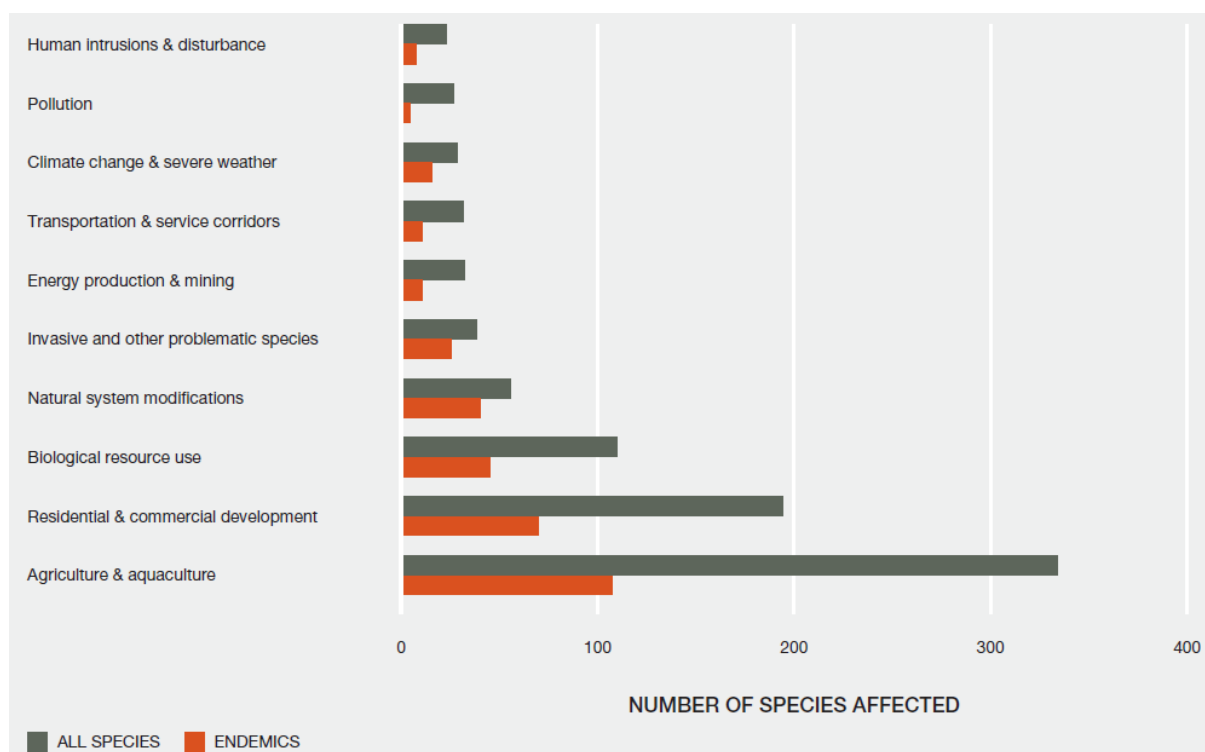


Figure 3.48 Main threats affecting reptiles in Europe and Central Asia according to species assessments published in the IUCN Red List (all species, grey; endemic species, orange (IUCN, 2017c)).

The major threat of habitat loss affects in particular relic forest species, and species of the steppe and semi-desert ecosystems, which are often not able to persist on agricultural and other transformed lands. *Eremias pleskei* (Armenia, Azerbaijan, Turkey and Iran) is listed as Critically Endangered, based on a population decline of more than 80% over ten years. Its natural sandy habitat has virtually disappeared due to human disturbance (Tuniyev Ananjeva et al., 2009). For habitat specialists, such as the Critically Endangered *Phrynocephalus horvathi* and *Acanthodactylus beershebensis* which are found on highly specific soils, habitat conversion can have a major impact (Ananjeva & Agasyan, 2009; Werner Disi & Mousa Disi, 2006). The disappearance of steppe vipers of the “ursinii-renardi” complex throughout most of the previously occupied habitats in Europe and Central Asia is associated with ploughing of steppes for agriculture (Tuniyev, 2016). Dam building has been detrimental to species such as *Rafetus euphraticus* in Turkey, causing drastic habitat alteration (Taskavak Atatür et al., 2016).

Significant threats include the illegal capture of commercially valuable species for the pet trade (all representatives of the vipers and turtles, and some species of lizards) in Turkey, the Caucasus and Central Asia. *Trionyx triunguis* softshell turtles have been reported as bycatch and have been killed, and nests destroyed, by fishermen who may perceive them as competitors; they are also affected by pollution, resulting in a listing of the Mediterranean subpopulation in Israel, Lebanon, Syria and Turkey as Critically Endangered (European Reptile & Amphibian Specialist Group, 1996). There are also reports of reptile poaching in Israel, which affects species such as *Uromastix aegypticus* (Yom-Tov, 2003). Prosecution of snakes continues in the area, especially in Turkey, the Caucasus and southern regions of Russia, and is associated with low levels of environmental education.

Invasive predator species play a particularly important role for island species, such as the Canary Island genus *Gallotia* (four of the eight species are Critically Endangered). Climate change is likely to play a major role in the region in the future. Climate change has led to an increase in summer temperatures and length of the dry summer period in the western Caucasus, resulting in a reduction of habitats of

11446 mesophylic Colchis reptile species (*Darevskia derjugini*) and an increase in the number of eastern
11447 Mediterranean snakes (*Hierophis caspius*, *Platiceps najadum*) on the Black Sea Coast (Tuniyev, 2012)

11448 Other threats, such as pollution, are less prominent in the IUCN Red List data; however, a recent risk
11449 evaluation of pesticide use to protected European reptiles suggests that ten species, including all six
11450 Habitat Directive Annex II turtles, are at above-average pesticide risk (Wagner et al., 2015).

11451

11452 3.4.5 Amphibians

11453 **Status and trends**

11454 Europe and Central Asia is highly diverse with, for example, thirty-five percent of the world's newt and
11455 salamander species (26 species of the family Salamandridae) present in Europe, extending from Iceland
11456 in the west to the Urals in the east and from Franz Josef Land in the north to the Mediterranean in the
11457 south.

11458 A total of 74 amphibian species are known in Western, Central and Eastern Europe, with the highest
11459 numbers occurring in France, Italy, Spain and the Balkans (20-30 species each) (Corbett, 1989). Fifty-
11460 nine percent of amphibian species (Temple & Cox, 2009) have declining populations. In the western
11461 Palearctic (i.e. European region and part of Asia with Turkey and the Caucasian region), species
11462 richness decreases with increasing latitude for amphibians and reptiles (Meliadou & Troumbis, 1997).

11463 Amphibians represent the third most endangered group of vertebrates in the European Union , with
11464 23% of species (19 species out of the 83 assessed) considered as threatened (Temple & Cox, 2009)
11465 (**Figure 3.49**). According to the Habitat Directive, more than two-thirds of the amphibian species
11466 assessed by European Union countries by biogeographical region (104) have an unfavourable
11467 conservation status. About 59% of European amphibian populations are declining with a further 36%
11468 stable and only 2% on the increase. These declines seem to have worsened over the past 25 years and
11469 amphibians are now more threatened than either mammals or birds (Beebee & Griffiths, 2005).

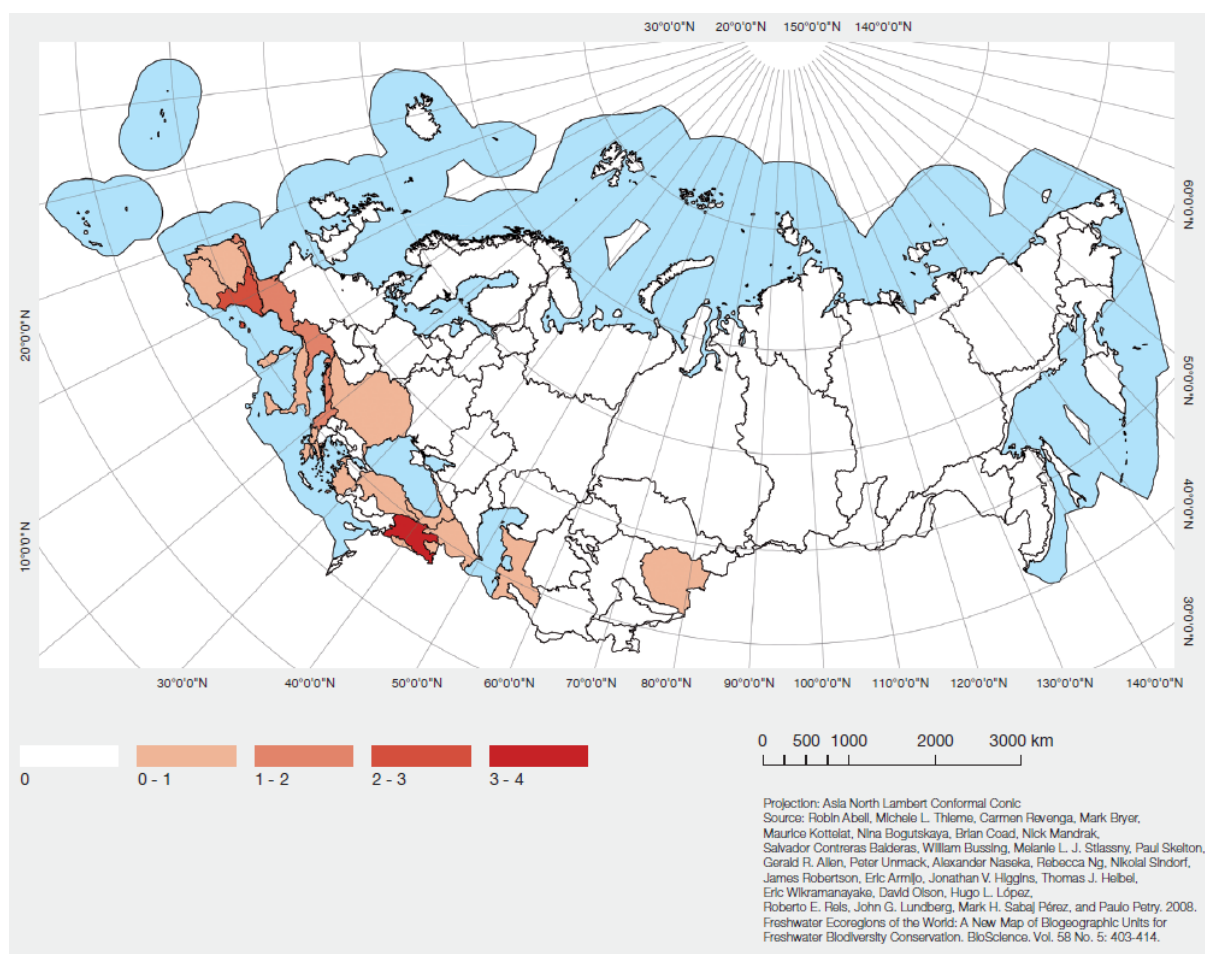


Figure 3.49: Number of globally threatened amphibian species by freshwater Ecoregion.

The recent Red list of European amphibians (Temple & Cox, 2009) has highlighted that about 23% of European amphibians (85 species in total) are threatened and show declining populations. This is even more significant given that 74% of European amphibians are endemic (only found in Europe) and that these endemic species tend to be more threatened within Europe.

Drivers of change

The three main causes for amphibians decline in the region are: 1) that fewer habitats available for these species, and what remains is often in small and isolated patches; much of the habitat has become less suitable through destruction or transformation, e.g. urbanization with roads, drainage and water pollution (Hamer & McDonnell, 2008) and with the loss of areas managed by traditional means (Hartel, Schweiger, Öllerer, Cogălniceanu, & Arntzen, 2010), more intense fish farming and recreational activities; 2) Climate changes, which threaten species particularly in areas where water and humid habitats are already scarce and expected to become even drier (Araújo, Thuiller, & Pearson, 2006); 3) Introduction of alien species, including the chytrid fungus, which is a particularly virulent disease affecting the skin and nervous system of adult amphibians and the mouthparts of their larvae, and responsible for amphibian declines worldwide (fatal for many species) (Duffus & Cunningham, 2010; EU, 2009). These three factors may also interact to exacerbate each other. In addition, there is rising concern that the impact of pesticides on amphibians has been underestimated and that pesticides could locally be a cause of amphibian population declines (Brühl, et al. 2013). While amphibians are generally declining, in the absence of the above mentioned drivers they can be well represented in

11492 traditionally managed landscapes by stable populations and species rich communities (Hartel,
11493 Schweiger, Öllerer, Cogălniceanu, & Arntzen, 2010).

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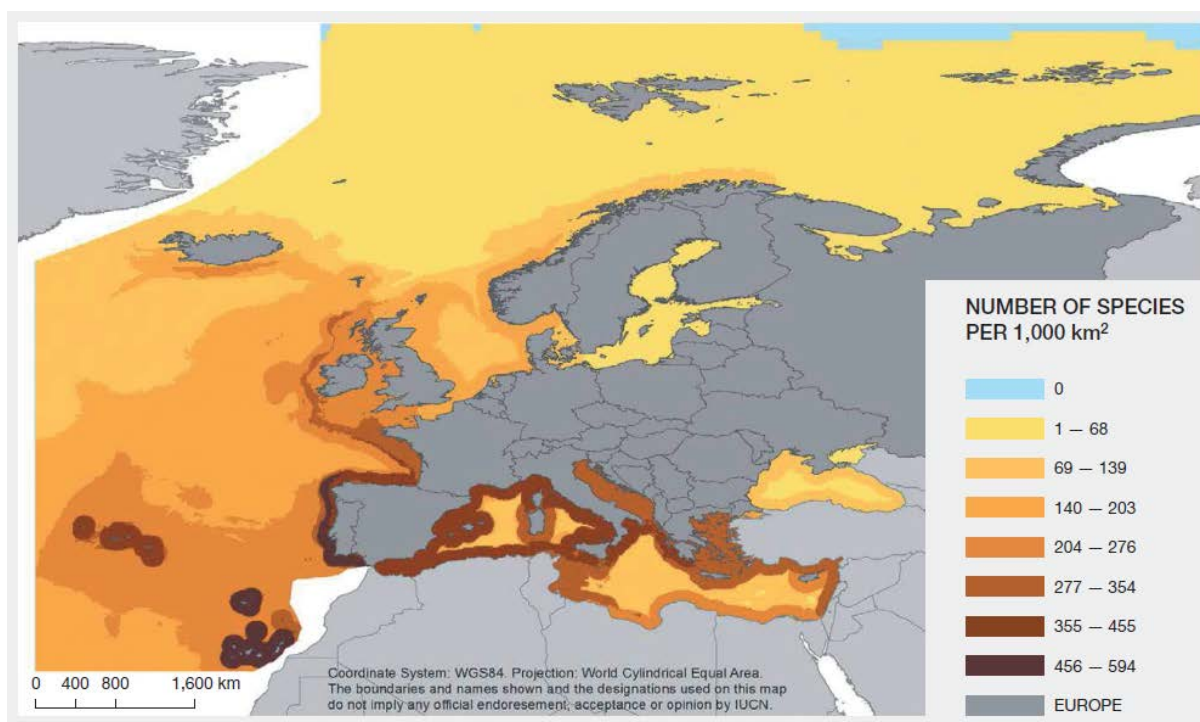
11495 3.4.6 Fishes

11496 3.4.6.1 Marine fishes

11497 **Status and trends**

11498 There are considerably more species of fish in all marine areas surrounding Europe and Central Asia
11499 than those known to consumers from markets. For example, reported species richness is around 100
11500 in the Caspian Sea (Mitrofanov & Mamilov, 2015), 833 in the Far Eastern seas of Russia (Volvenko,
11501 2014), 650 in the Mediterranean Sea (United Nations, 2016), 200 in the Black Sea (Bologa & Sava,
11502 2012), and 100 in the Baltic Sea (HELCOM, 2009). Species richness tends to be comparatively higher in
11503 coastal areas, along the continental slope, and towards the south (**Figure 3.50**). Due to the high
11504 mobility of fish and the open nature of marine waters, there are intense, complex, competitive
11505 interactions within fish communities, which naturally leads to large differences in the population
11506 biomasses of different species (Fung, Farnsworth, Shephard, Reid, & Rossberg, 2013).

11507 In a comprehensive assessment of threats to European marine fish species, Nieto et al. (2015) found
11508 that 59 species (7.5%) were threatened. All 15 Critically Endangered species amongst these are
11509 Chondrichthyes (sharks, rays, and similar). The low resilience of these organisms is due to their life-
11510 history traits (slow reproduction and small number of offspring). Indeed, poor conservation status is
11511 most common for Chondrichthyes and other species with large body size, which also infers slow
11512 reproductive rates (Fernandes et al., 2017b). Among the largest species, many migrate over large
11513 distances. Of species with assessed stock, including those considered overfished, Fernandes et al.
11514 (2017) found only a small proportion to be threatened. Considering trends in the sizes of species
11515 populations, 8.4% were found to be declining, mainly due to overfishing, but also coastal development,
11516 energy production and mining, and pollution. Increasing trends were found for 1.7% of populations.
11517 For about 69% of marine fish species data for European Union waters is insufficient to estimate trends
11518 (EEA, 2015).



11519

Figure 3.50: Species richness of European marine fishes (A. Nieto et al., 2015).

Good data on trends is available for the North East Atlantic shelf seas, which permits application of trend analyses that take into account that fish populations can naturally fluctuate over wide ranges (Greenstreet et al., 2012). These reveal recovery of a statistically significant number of fish species classed as sensitive (based on their recruitment pattern) in the Celtic Sea, but not yet in the North Sea (OSPAR, 2017b). Yet, in both of these highly fished areas the number of recovering species has increased over time (OSPAR, 2017b) as a result of changes in fisheries management.

Considering the strong relationship between conservation status and body size (Fernandes et al., 2017b) and the slow recovery dynamic of overall fish community size structure (Fung et al., 2013), the state of marine fish communities can be assessed based on the typical length (Lynam & Rossberg, 2017) of fish caught in surveys. Using this measure, (OSPAR, 2017b) showed that demersal fish communities continue to deteriorate in some parts of North East Atlantic shelf, e.g. in the southern parts of the North Sea and along the continental slope (**Figure 3.51**), while in other areas recovery can be observed. This illustrates the surprisingly localized impact of varying exploitation patterns on the status of marine fish communities. For pelagic fish communities, trends in either direction tend to be less apparent (OSPAR, 2017b). For the Baltic Sea, good status of piscivores and of cyprinids/mesopredators (in terms of total biomass) is reported by (HELCOM, 2017a).

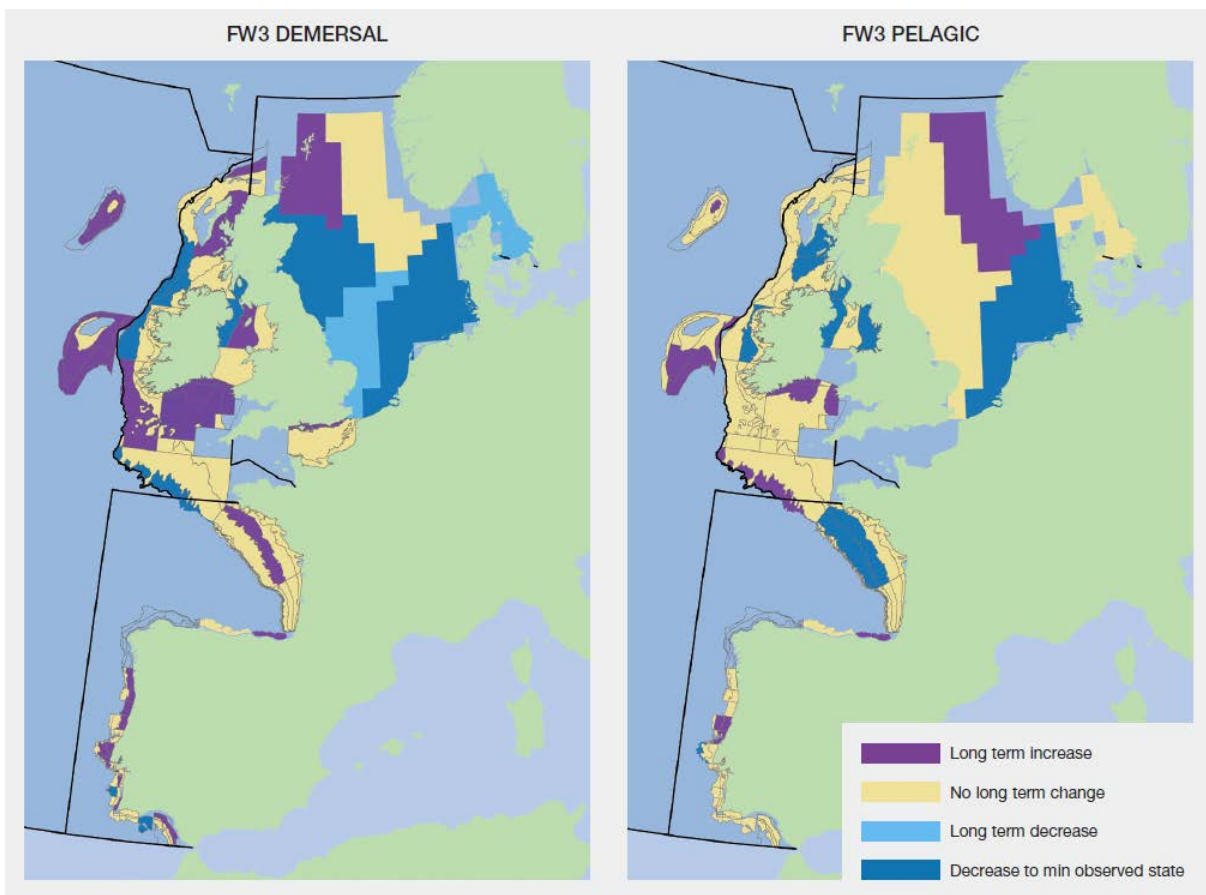


Figure 3.51: Spatial pattern of trends in the typical length of fish caught in surveys (OSPAR, 2017b)

For status and trends of fish biodiversity in the Mediterranean Sea, indigenous and local knowledge offers important information that is unavailable from scientific surveys. Combined survey data and interviews with local fishermen in the Spanish Mediterranean Sea and Gulf of Cadiz, (Coll et al., 2014) documented overall declines in abundances and maximum sizes of fish. Potential extirpations, notably

of Chondrichthyes, were reported as well. Small fish were reported to have proliferated, potentially due to a trophic cascade effect. A meta-analysis by Vasilakopoulos et al., (2014) of 42 stocks of nine species in 1990–2010 covering the entire European Mediterranean and Black Seas comes to similar conclusions: exploitation rates have been increasing, and stocks are shrinking and are being harvested too early in their lifecycle. In the Black Sea, two sturgeon species were recently declared extinct (Yankova et al., 2014).

For the North-West Pacific a digital database covering the years 1977-2010 is available (Volvenko, 2014), but coverage has been argued not to be sufficient even to reveal specific trends. In data from pelagic trawl surveys, Ivanov and Sukhanov (2015) document a pronounced decline of pelagic fish biomass and diversity in the Russian Waters of Far Eastern Seas from the 1980s to the mid 1990s, and a pronounced recovery in the subsequent period until 2009, without providing a clear attribution.

Drivers of change

Overfishing is still the main threat to marine fish across Europe and Central Asia. Throughout the region, the expansion of industrial fishing after the Second World War and the resulting over-exploitation of fish led to pressures on biodiversity at community level, except in the Arctic Ocean where only specific stocks appear to be affected (CAFF, 2013). However, during the last few decades changes in management practices have led to improvement in the status of stocks and release of pressures on fish-communities as a whole, especially throughout the North East Atlantic Shelf Seas. In other parts of Europe and Central Asia, institutional barriers to coordinated action and the relatively high costs involved in regular stock assessments have so far prevented demonstrable recovery of fish communities.

Other drivers are also responsible for the negative trend identified, especially different forms of pollution in enclosed seas (Black, Mediterranean, Baltic, Caspian and Aral Seas); coastal developments degrading and sometimes extirpating coastal habitats important as nurseries; energy production; and mining. These are sometimes exacerbated by climate change. In the Black Sea, for example, ecosystem disruptions by eutrophication and invasive species continue to impact fish communities (Bologa & Sava, 2012). In rivers feeding the Caspian and Aral Seas construction of dams has led to drastic reductions in the abundance and extinction of some migratory fish (Mitrofanov & Mamilov, 2015).

3.4.6.2 Freshwater fishes

Status and trends

The European Union contains 546 native species of freshwater fish from of which, according to IUCN assessments, at least 37% are threatened and 4% are considered near threatened (Freyhof & Brooks, 2011). This is currently the second most threatened taxonomic group assessed, after freshwater molluscs. The highest diversity of fish species can be found in the Danube River with 103 species, followed by the Volga River with 88 species (**Figure 3.52**). Southern Europe is the region with the highest number of local endemic species, with natural ranges limited to one or few streams, springs or rivers, and several of them have only recently been discovered. They are therefore still not well known to conservationists and national or regional governments (Freyhof & Brooks, 2011). Central Asia is home to approximately 120 fish species of which 30 are on the Red List (Karimov et al., 2009; Milner-Gulland et al., n.d.). Several fish species naturally entered the floodplains from the north (Siberia) and west (Western Asia). Many Eurasian fish species have formed sub-species in Central Asia (e.g. Amudarya trout, Aral roach, Aral asp, Samarkand khramulya, Aral bream) and contribute to high endemic diversity (e.g. Aral Sea basin) (Berg, 1949; Nikolsky, 1971; Turdakov, 1963).

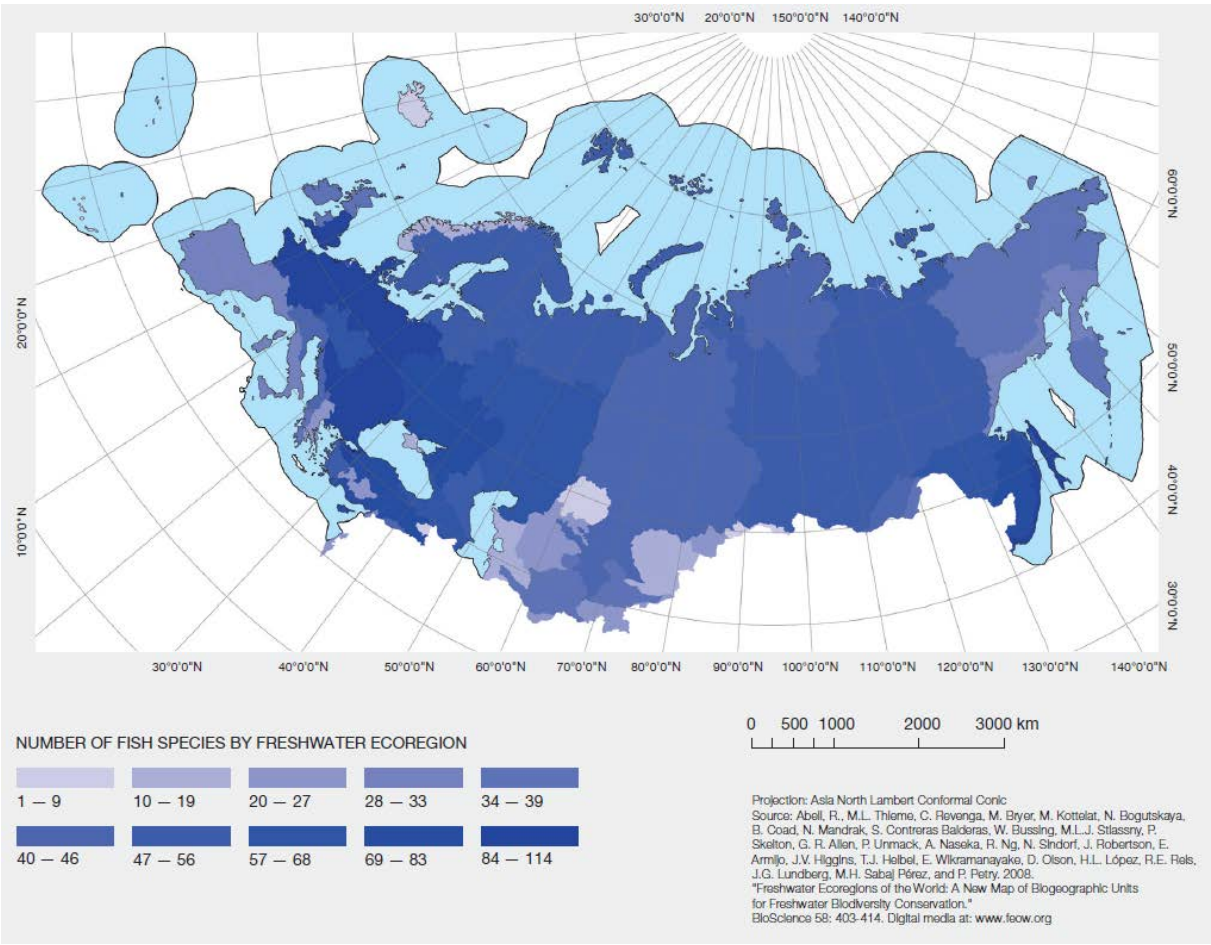


Figure 3.52: Distribution of freshwater fish species richness across Europe and Central Asia.

There are no other groups of freshwater fishes in Europe and Central Asia that show higher threat levels than anadromous species (e.g. sturgeons, herrings of the genus *Alosa*, salmonids and some whitefishes of the genus *Coregonus* and *Stenodus*, (Freyhof & Brooks, 2011)). Trends also highlight a crisis with, for example, a sixfold decline in Baltic salmon catches between 1990 and 2009 (Mannerla et al., 2011).

Although these figures are at a European level and such detailed data are difficult to access for Central Asia, it is expected that these trends and the observed decline of about 17% of European freshwater fishes populations are also true in Central Asia. In Europe, only 1% of freshwater fish species populations are on the increase, against 17% declining and 6% considered stable (Freyhof & Brooks, 2011). However, there is a lack of reliable data on trends, and therefore the actual percentage of species that is declining is probably largely underestimated. In fact, population trends for 76% of all fish species in Western Europe, Central Europe and western parts of Eastern Europe still remain unknown because almost no population trend data exist from most countries (Freyhof & Brooks, 2011). Thus, monitoring data for freshwater fish species diversity and abundance is urgently needed in order to accurately measure population trends and improve the accuracy of future Red List assessments. The highest number of threatened freshwater fish species is found in the south of the European subregions **Figure 3.53**).

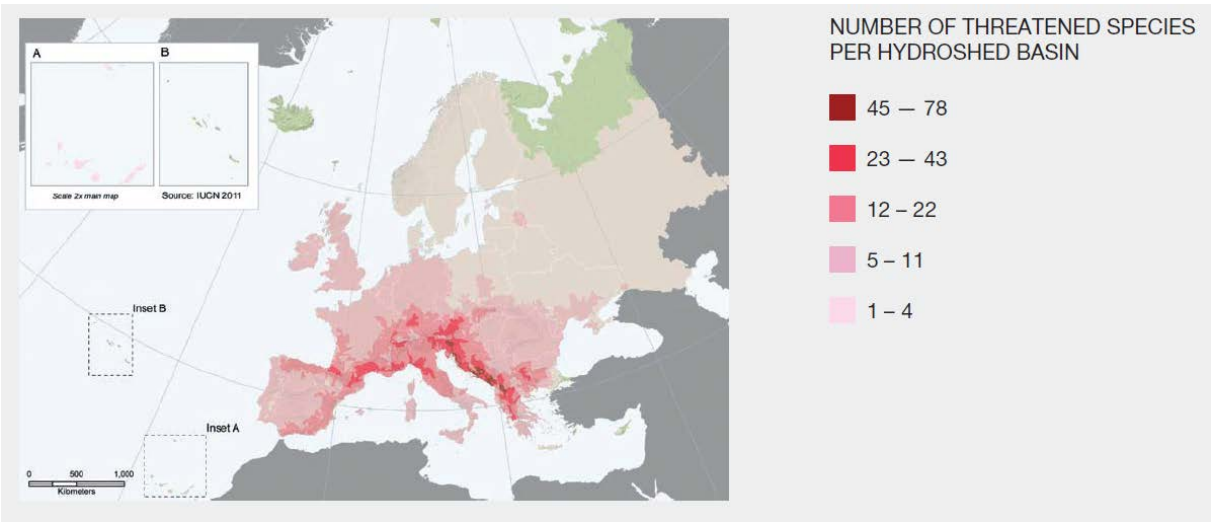


Figure 3.53: Distribution of threatened freshwater fish in Europe (as defined by the European Environment Agency, including Russia up to the Urals). Source: Freyhof & Brooks (2011). European Red List of Freshwater Fishes. Luxembourg: Publications Office of the European Union.

Villéger and co-authors (Villéger, Grenouillet, & Brosse, 2014) have also shown that among current European fish assemblages, functional homogenization (reduction in diversity of functional traits over space and time) exceeds taxonomic homogenization (reduction in species diversity) six-fold. In addition, non-native species originating from other parts of Europe played a stronger role in this homogenization process than non-native species from outside Europe, while extinction did not play a significant role.

Drivers of change

A main threat for freshwater fish species in Europe and Central Asia is the destruction or modification of their habitat. This includes a change in the river continuum with the construction of dams and weirs that fragment populations. This has direct consequences for the remixing of upstream-downstream genetic pools and for free seasonal migrations. In addition, it leads to a deep modification of flow patterns transforming lotic habitat into lentic ones and, as a result, changing species assemblages, functional diversity and homogenization of freshwater fish communities. Water abstraction is one of the most important threats to European freshwater fishes, especially in the Mediterranean basin where illegal water abstraction is widespread (Freyhof & Brooks, 2011). Many countries in southern parts of Western and Central Europe still lack effective enforcement of legislation that could limit the damages of excessive water abstraction to biodiversity. The increased frequency and intensity of droughts are worsening the situation.

Another important threat is pollution of industrial, agricultural and domestic origin (e.g. hormone disruptors from polymery and paint industries that cause reproductive disorders, in particularly in aquatic organisms). In lakes, for example, the percentage of land used for agriculture in the catchment (which leads to anthropogenically enhanced productivity) is associated with several changes in fish communities such as increase in species richness and abundance and a decrease in their community average body size (Sandra Brucet et al., 2013). At least eight of the 13 globally extinct species of European freshwater fishes were victims of water pollution and lake eutrophication, mainly during the late 19th and in the 20th centuries (Freyhof & Brooks, 2011). However, due to European Union regulation, the water quality of rivers and lakes has improved in recent decades and this has helped to improve conditions for many fish species. In Central Asia and the Caucasus, however, about one third of untreated sewage goes directly into regional rivers. Pollution as a result of change in land use is still

relevant in these regions, in particular the increase in siltation due to agricultural practice and destruction of riparian vegetation, which used to act as an important buffer zone to freshwater ecosystems.

Climate change is also affecting fish populations, particularly in the coldest and the most arid parts of Europe and Central Asia. Jeppesen and co-authors (Jeppesen et al., 2012) published long-term (10–100 years) series of fish data from 24 European lakes. Along with a temperature increase of about 0.15–0.3°C per decade, considerable changes have occurred in either fish assemblage composition, body size or age structure during recent decades, with a shift towards dominance of warm water species. These changes took place despite a general reduction in nutrient loading. Similar responses to warming were found in river fish (Daufresne, Lengfellner, & Sommer, 2009). Arctic charr has been particularly affected. In the arid conditions of Central Asia, agriculture relied on the extensive use of irrigation. From the 1950s to the 1980s, about 40 reservoirs (total water volume more than 57 km³), more than 150,000 irrigation canals, more than 100,000 drainage canals and 10 lakes for residual water storage (with an area of about 7,000 km²) were created. These large-scale constructions impacted local fish communities. Dams on the rivers blocked passage to spawning areas for migratory fishes. As a result, fringebarbel, sturgeon and Aral barbell vanished from local waters. All fish populations in the floodplain (such as common carp, asp, sabrefish, bream, roach, pike-perch) have established new stocks in all newly constructed man-made reservoirs and lakes. Also, the abundance of riverine fishes such as shovelnoses (three species), pike-asp, zarafshon dace and minnow dramatically decreased due to a change in flow and a reduction of turbidity in the river sections downstream of the reservoirs (Berg, 1949; Kamilov, 1973; Nikolsky, 1938; Turdakov, 1963).

Another key threat in Central Asia is water salinization (Jeppesen et al., 2015). For example, in the three decades from 1961 to 1991 the Aral Sea's salt concentration increased from 10.2 ppt to 35 ppt (Pavlovskaya, 1995). Freshwater fishes cannot adapt to these levels of salinity and many therefore became extinct. The discharge of drainage waters from irrigated fields and industries has also led to salinization and chemical pollution of rivers. Parts of many Central Asian rivers have been contaminated by phenols, oil products, heavy metals, pesticides and nitrogen compounds (Pavlovskaya, 1995).

In recent years there have been many examples of alien pathogen and parasite introductions in Europe and Central Asia and their dramatic effects on aquatic wildlife and biodiversity, with several having a direct impact on fish biodiversity and ecosystem services (Peeler et al., 2011). For example, *Anguillicola crassus*, a parasitic nematode, directly impacted wild populations of the European eel, *Anguilla anguilla*. The most severe of all, identified in the last decade as a major threat to European fish diversity (Gozlan, St-Hilaire, Feist, Martin, & Kent, 2005), is the rosette agent, a generalist fungal-like pathogen introduced along with the Asian gudgeon (*Pseudorasbora parva*) and responsible for the rapid decline of endemic fish species across Europe and Central Asia (Ecran et al., 2015). This pathogen and its host have caused the decline and extinction of native population across Europe - some of them endemic or not yet even described. Most of these introductions across the region occurred via the aquaculture trade, fisheries or ornamental purposes (Boll et al., 2016; Gozlan, 2016).

3.4.7 Terrestrial Invertebrates

Status and trends

The diversity of terrestrial invertebrates in Europe and Central Asia is unevenly explored, with a substantial lack of knowledge for most taxa, especially for below-ground (soil) fauna. Above-ground terrestrial invertebrates are generally better known, with described insect species numbering in the

order of 100,000 in Europe²⁸, about 80,000 for Kazakhstan (The Fifth National Report on Progress in Implementation of the Convention on Biological Diversity 2014), and about 30,000 for the Russian Far East (Lelej & Storozhenko, 2010). Scientific knowledge of certain groups is rapidly increasing. For example, the number of described fly (Diptera) species in the Palearctic was 29,579 according to a catalogue published in 1992 (Soós, Papp, & Oosterbroek, 1992) and increased to 44,894 in 2009 (Pape, Bickel, & Meier, 2009), an increase of about 15,000 species new to science or to the region. Heteroptera species numbered 9,365 in 2006, an almost 10% increase compared to 1995 (Aukema, Rieger, & Rabitsch, 2013). Bumblebee species numbers increased from 23 to 33 in the 170,500 km² large Tuva Republic (Russia) based on a survey in 2013 (Kupianskaya, Proshchalykin, & Lelej, 2014). For several speciose taxa, there is no information even on species presence, even though some of these include taxa with extreme importance for ecosystem functions, like Hymenoptera (with many parasitoid species), or most soil organisms, contributing to biological control and pollination, or soil fertility, respectively. Despite their extremely high species richness, and importance for ecosystems services, only a very small proportion of species is assessed by the IUCN Red List (**Table 3.10**).

Trends are known for certain groups, such as butterflies. Major declines of butterfly populations occurred in the 1950s-1970s due to agricultural intensification in Western Europe but one third of species are still declining (van Swaay et al 2010). Bees (honeybees and wild bees including bumblebees) have been recently evaluated as pollinators by IPBES (2016b). Many wild bee species have been declining in Western Europe. For example, 50% of bee species are threatened in some European countries, while data for other regions are currently insufficient to draw conclusions (IPBES, 2016b). Better taxonomic coverage exists for terrestrial invertebrates of community interest according to the Habitat Directive and monitored throughout the European Union. One quarter of these species (arthropods, molluscs and others) have deteriorating conservation status (EEA, 2015f). A recent meta-analysis found a 77% decline in flying insect biomass across 63 protected sites in Germany from 1987 to 2016, likely due to agricultural intensification in the surrounding fields, with protected sites therefore acting as ecological traps (Hallmann et al., 2017). This analysis suggests that the extent of insect decline in Europe has been greatly underestimated.

In Europe alone, the update of the database of invasive species²⁹ (Roques et al., 2009), lists 1,590 terrestrial arthropod species of non-European origin established in Europe, including 1,390 insects, 47 spiders, 102 mites, 34 myriapods and 17 crustaceans (Kenis & Branco, 2010).

Local ecological knowledge on invertebrates is scarce, including their status and trends over the last decades. Some culturally salient invertebrate species have, however, functioned as important keystone species in the lives of certain communities (Marian, 1903; Ulicsni, Svanberg, & Molnár, 2016). Indigenous and local knowledge can be a valuable information source in understudied regions for those species that migrate northwards as a consequence of climate change. Some of these species (e.g. mosquitos and ticks) may have (or already have) a strong but yet undocumented impact on local wild and domestic livestock.

Drivers of change

Environmental changes may rapidly disrupt biotic interactions (insect-insect, plant-insect, invertebrate-nutritional source). Species involved in species-specific interactions (e.g. pollination, foraging) are particularly sensitive to environmental changes. The extinction of a butterfly species may be locally explained by the extinction of its host plant. A parallel decline in pollinators and insect-pollinated plants in Western Europe favoured wind-pollinated plants, and contributes to global

²⁸ The countries included in this checklist are listed here <http://insectoid.info/checklist/insecta/europe/>

²⁹ Delivering Alien Invasive Species Inventories for Europe <http://www.europe-aliens.org/>

11732 homogenization (Biesmeijer et al., 2006, Carvalheiro et al., 2013). Beyond independent taxon-based
 11733 extinctions, the possible cascading effects of species loss are often neglected, which are considered
 11734 likely to greatly contribute to general homogenization and species loss (Kearns, Inouye, & Waser, 1998;
 11735 Koh, 2004).

11736 Honeybees suffer from colony collapse disorder, which also affects the production of colonies (Breeze
 11737 et al., 2014; Kovács-Hostyánszki et al., 2016). Many of the environmental threats to bee diversity are
 11738 associated with intensified agriculture (shifting agricultural practice linked to pollution, pesticides and
 11739 the increasing intensification of farming), as well as change in land use and climate (Nieto et al., 2014;
 11740 Goulson, Lye, & Darvill, 2008). Similar trends (sensitivity to agricultural intensification, change in land
 11741 use and climate) were also observed in other kinds of insects acting as pollinators (IPBES, 2016b). Many
 11742 wild bees and butterflies have been declining in abundance, occurrence and diversity at local and
 11743 regional scales, as it has been recorded in Western Europe (IPBES, 2016b).

11744
 11745 **Table 3.10: Number and trends of red listed species, and the major drivers of change for five groups**
 11746 **with diverse ecology. The area covered is Western Europe, Central Europe, and part of Eastern**
 11747 **Europe (continent of Europe).**

	Number of species	Increasing (%)	Stable (%)	Decreasing (%)	Unknown (%)	Major drivers
Terrestrial molluscs (Cuttelod, Seddon, & Neubert, 2011b)	246	0.6	39.8	6.3	53	Urbanisation, agriculture, recreation and other human activities, change in fire regime, roads and shipping lanes
Bees (Nieto et al., 2014)	1942	0.7	12.6	7.7	79	Agricultural expansion and intensification, livestock farming and ranching, pollution (agricultural and forestry effluents), Residential and commercial development (urban sprawl), fire and fire suppression, climate change
Butterflies (Chris Van Swaay et al., 2010)	482	4	55	31	10	Agricultural intensification, abandonment, climate change (including droughts), change of woodland management, tourism and recreation
Saproxyllic beetles (Nieto & Alexander, 2010)	436	2.3	26.8	13.8	57.1	Logging and wood harvesting
Grasshoppers, Crickets, Bush-crickets (Hochkirch et al., 2016)	1082	2.2	7.6	30.2	59	Livestock grazing, arable farming, increasing wild fire frequency, urbanisation and infrastructure, touristic development

11748

3.4.8 Freshwater invertebrates

Status and trends

No assessment has been performed on freshwater invertebrates for the whole of Europe and Central Asia except molluscs and dragonflies. In the interest of highlighting the magnitude of threat facing freshwater invertebrates, the next paragraph reports some global statistics under the assumption that figures from Europe and Central Asia are not dissimilar from global ones.

The great majority of freshwater animals are invertebrates, mostly insects (60%) and crustaceans (10%) with molluscs being the most diverse but also threatened group of animals, with at least 43.7% of the species (373 species) considered as threatened (Cuttelod et al., 2011b). In the Red List assessment, IUCN experts have included 7,482 species divided in odonates, molluscs, crabs and crayfish as these taxonomic groups have received extensive attention. Therefore, these groups represent the best available dataset to quantify the extinction risk among freshwater invertebrates. It includes assessments of 1,280 species of freshwater crabs, 590 species of crayfish, 1,500 species of freshwater molluscs (30% of all known species) and 1500 species of dragonflies and damselflies (26% of all known species). However, the precise level of threat is unknown as there is a high number of species (2,504), which have a Data Deficient status. Therefore, the level of threat is between 23% and 56 % depending on whether we assume that no species or all data deficient species are threatened. Currently, 131 species are classified as extinct with an additional four as extinct in the wild. The most threatened groups are gastropods (from 33%-68 %, respectively assuming no DD species are threatened or all of them are), bivalves (26%-49%), crayfish (24%-47%), crabs (16%-65 %) and dragonflies (9%-44%). Due to a high proportion of range-restricted species living in highly specialized habitats subject to pollution (including sedimentation) or habitat destruction, freshwater gastropods have the highest percentage of threatened species (51%). This results in 3% of gastropods and 5% of bivalves being classified as extinct with the greatest number of extinctions reported for molluscs with more than that reported for birds, mammals and amphibians.

Concerning Europe, distribution and population of many widespread species of molluscs have been declining since the 1880s, with the greatest losses between 1920 and 1960 due to habitat change and degradation (Cuttelod et al., 2011b). Many species of European dragonflies have shown a dramatic decline in distribution and abundance since the second half of the 20th century (Kalkman et al., 2010; Sahlén et al., 2004), particularly in the south of Europe due to the dessication of their habitats. Overall, 15% of European dragonfly species are threatened and 24% of assessed populations are declining (only 12% of species have not been assessed). At least in parts of Europe, some of the species of dragonflies considered threatened have recovered since the 1990s as result of improved water management (Kalkman et al., 2010). The number of Plecoptera species decreased due to water quality degradation and physical alteration of streams and rivers, particularly those inhabiting lowland rivers of industrialized Central European countries (Fochetti & Tierno De Figueroa, 2008). *Taeniopteryx araneoides* (Klapálek) and *Oemopteryx loewi* (Albarda), once common in large Central European rivers, are now extinct (Zwick, 2004). These are among the very few documented cases of extinction in insects. Although some invertebrate species have been lost in British rivers since 1800 (four out of 30 stoneflies, three out of 37 dragonflies, three out of 193 cais, and six out of 386 water beetles), the diversity of invertebrate communities has overall increased in recent decades largely due to improvements in wastewater treatment (Moss, 2015). Family level richness increased on average by nearly 20% from 1991 to 2008, particularly in urban catchments, with a widespread shift towards taxa of well-oxygenated and less polluted waters.

Drivers of change

Water pollution, including nitrates and phosphates from agricultural sources, are the main threat to freshwater invertebrates (e.g. Cuttelod et al. (2011b)). Habitat modifications linked to change of flow patterns as a result of dam construction and, specifically in Europe, as a result of water abstraction for domestic supplies and crop irrigation, threaten about 26% of freshwater invertebrate species. In addition, habitat modifications due to change in land use, including decline of riparian macrophytes as a result of floodplain drainage, for example for housing development projects, are responsible for 19% of threatened freshwater species. A review by Stendera and co-authors (Stendera et al., 2012) showed an overall decreasing trend in abundance, richness and diversity of invertebrates due to all these stressors, predominantly land use, eutrophication, and habitat destruction.

Alien species introduced as a result of human activities were also found to have a role in causing a decrease and change in invertebrate community structure. For example, invasions of amphipod species from Ponto-Caspian rivers were enabled by the creation of canal networks interconnecting the major Eastern and Western European river systems since the late 1700s and later enhanced by intentional transfers of potential fish food organisms to hydropower reservoirs. The rate and range of the invasions have dramatically increased since the late 1980s and in the 2000s across these three subregions and many river communities are undergoing major change with the aggressive expansion of *Dikerogammarus villosus* (Väinölä et al., 2008). Another example is the North American euryhaline *Gammarus tigrinus*, which was introduced to Britain and then intentionally to Germany in 1957 to replace locally extinct native species and has since then broadly occupied river, lake, and estuarine habitats in Europe (Väinölä et al., 2008). Some *Mysids* autochthonous in the Ponto-Caspian region are also currently invading some aquatic ecosystems of Northern Europe (Leppäkoski et al., 2002). The impact of these species on native lacustrine and riverine ecosystems can be severe, including a reduction in zooplankton abundance, with concomitant negative effects on higher consumers (Ketelaars, Lambregts-van De Clundert, Carpentier, Wagenvoort, & Hoogenboezem, 1999). However, at least for molluscs, though invasive species are now widely present and have had an impact on some species, their presence impacts less than 5% of the threatened species (Cuttelod et al., 2011b). In addition, the introduction of diseases along with the introductions of alien crayfish species has also been a major issue with *Aphanomyces astaci*, the crayfish plague, responsible for the severe decline of the native European crayfish, *Astacus astacus*.

The effects of climate change on macroinvertebrates vary depending on the region and the taxon group (Domisch et al., 2013; Jähnig et al., 2012) and some studies at national scale have confirmed that, in England, for example, improved water quality through positive management better explained assemblages than increased winter temperatures (Durance & Ormerod, 2009). At a local scale Brown and co-authors (Brown, Hannah & Milner, 2007) found that a lower contribution of meltwater (from snow and glaciers) to streams significantly increased macroinvertebrate diversity, although some cold adapted taxa decreased in abundance. Some groups such as Trichoptera are potentially more at risk than others by changes in climate across Europe (Hering et al., 2009). Recently it has become evident that many dragonflies of temperate regions are responding, both in distribution and phenology, to global climate change (Kalkman et al., 2008). The ranges of common and widespread southern species are expanding in Europe but there is as yet no strong evidence that northern species are decreasing as a result of the rising temperatures, as might be expected. There is evidence that ranges are changing for Odonata (Moss, 2015), bugs (Hickling, Roy, Hill, Fox, & Thomas, 2006), Plecoptera, and aquatic beetles (Heino, 2002), and Diptera (Burgmer, Hillebrand, & Pfenninger, 2007).

Lake zooplankton has provided good examples of climate change effects on invertebrates. There is evidence of direct and indirect (through changes in hydrology) effects on seasonality, community composition, parasitism, grazing and production. For example, in the lake Muggelsee, in Berlin, zooplankton species with high thermal tolerances or rotifers that grow quickly at high temperatures

have become more common (Wagner & Adrian, 2011). The trend towards warm springs and summers has also affected the population dynamics of several cyclopoid copepods whose growth phase was prolonged both in spring and autumn (Gerten & Adrian 2002). Predatory Cladocera as well as filter feeders have also been affected by warming. In Lake Maggiore, Italy, there was a more than 10-fold increase in the mean annual population density of *Bythotrephes longimanus* between 1987 and 1993, due to warmer winter and spring temperatures (Manca & DeMott, 2009). *Bythotrephes* remained abundant and increased even more during the following ten years, as water temperature continued to increase. *Daphnia hyalina galeata*, the dominant grazer, and a prey of *Bythotrephes*, decreased sharply as *Bythotrephes* increased. Temperature increase in a series of Russian lakes was also associated with a shift from copepods to cladocerans, resulting in the highly unsaturated fatty acid content of the community falling and thus providing food of reduced quality for fish (Gladyshev et al., 2011) irrespective of timing.

Acidification of surface waters was a severe environmental problem, particularly in northern Europe, during the second half of the last century causing freshwater biodiversity loss. International action plans have led to chemical recovery of some surface waters due to decreased acid deposition, but acidification problems persist in some lakes and rivers. Long-term studies (1988-2007) have shown an overall weak recovery of invertebrate species as a response to chemical recovery in boreal lakes (Angeler & Johnson, 2012). In the Vosges mountains (France), Guerold and co-authors (Guerold et al., 2000) found a high reduction in diversity for many aquatic species, and among them Molluscs, Crustaceans and Ephemeroptera disappeared totally from strongly acidified streams. In addition, there is evidence that acidification has simplified some invertebrate communities in UK streams and probably made them more vulnerable to climate effects, which conversely might offset biological recovery from acidification (Moss, 2015).

3.4.9 Vascular plants

Status and trends

Of the estimated 32,000 vascular plant species occurring in Europe and Central Asia, IUCN evaluated 2483 (approx. 8%) in the Red List of Threatened Species. Of these, 810 (32.6%) are Threatened (270 Critically Endangered, 287 Endangered and 253 Vulnerable). Another 166 are listed as Near Threatened. Four species are Extinct and four species Extinct in The Wild (likely strongly underestimated). There is a remarkably high percentage of species with unknown population trend (approx. 46%). About one fifth of the evaluated plants (19.6%) show a declining population trend, whereas about one third (31.6%) is stable. Only a very small proportion (2.5%) has increasing population sizes. However, these percentages might be biased, as it is likely that more threatened than un-threatened species have been evaluated by IUCN. Especially the total percentage of species with increasing population sizes is likely larger, as many generalists tend to expand their range sizes (Bilz et al., 2011b; IUCN, 2017b).

At the national level, all occurring species have often been evaluated in Red Lists and the average proportions of extinct and endangered species are often quite high (e.g. in densely populated regions), reflecting the local decline of species richness and of population sizes (Aizpuru et al., 2000; Bornand et al., 2016; Broggi et al., 1984; Cheffings & Farrell, 2005; Conti et al., 1992; Curtis et al., 1988; Icelandic Natural History Institute, 1996; Lilleleht, 1998; Ludwig & Schnittler, 1996; Marhold et al., 1999; Millaku et al., 2013; Niklfeld, 1999; Olivier et al., 1995; Oltean et al., 1994; Parfenov et al., 1987; Phitos et al., 1995; Procházka et al., 2000; Rakonczay, 1989; Rassi et al., 2010; Latvian Academy of Science, 1997; Shelyak-Sosonka, 1996; Silic, 1996; Sugar, 1994; Vangjeli, Ruci, & Mullaj, 1995; Vangjeli, Ruci, & Hoda,

11887 1997; Velchev et al., 1984; Weeda et al., 1990; Westling, 2015; Wind & Pihl, 2004; Wraber et al., 1989;
11888 Zarzycky et al., 2001).

11889 *Europe as defined by IUCN* (West and Central Europe, Eastern Europe up to the Ural and Caucasus
11890 region) harbors more than 20,000 vascular plant species (Euro+Med, 2017). Of these, 1,826 species
11891 have been evaluated for the European Red List of Vascular Plants, comprising species listed as priority
11892 for conservation in multilateral environmental agreements (Habitats Directive, Bern Convention,
11893 CITES, EU Wildlife Trade Regulation), crop wild relatives and aquatic plants. About one third (467
11894 species; 26%) is Threatened with Extinction. 45% and 10% of the MEA-listed species are listed as
11895 Threatened or Near Threatened, respectively, 12% and 5% of the crop wild relatives, and 7% and 7%
11896 of the aquatic species. The percentage of species with an unknown population trend is notable, as this
11897 has been determined for only half of the crop wild relative species (48%), approx. one third of the
11898 policy species (37%) and about one fifth (19%) of the aquatic plants. Of the evaluated plants, 38% of
11899 the policy species, 16% of the aquatic plants and 11% of the crop wild relative species are declining,
11900 while the populations of 22% of the species listed in multilateral environmental agreements, 39% of
11901 the crop wild relatives species, and 64% of the aquatic plants are stable. However, population trend
11902 analyses are often based on survey data from only a small part of the species range or on subjective
11903 assessments based on known threats or habitat decline. Moreover, these percentages might be biased
11904 as probably more threatened than unthreatened species have been evaluated (Bilz et al., 2011b). Sixty-
11905 four species are known to have gone extinct (Silva et al., 2008). Currently 6,190 endemic taxa (164
11906 species groups, 5191 species, 835 subspecies) are listed for Europe and about 50% of them are in
11907 danger of extinction. About 3,000 taxa are considered as local endemics, only occurring in one country
11908 or one archipelago. Particularly high numbers of endemic taxa are found in the Mediterranean and the
11909 Macaronesian Islands (Blondel, Aronson, Bodiou, & Boeuf, 2010; Bruchmann, 2011; Cañadas et al.,
11910 2014).

11911 Eastern Europe, and more particularly Russia, harbors about 11400 vascular plant species (Chandra &
11912 Idrisova, 2011), 676 of them are considered threatened (Ministry of Natural Resources and
11913 Environment of the Russian Federation, 2015). Only 53 species are evaluated in the IUCN Red List
11914 (IUCN, 2017b).

11915 Central Asian countries harbor at least 7,000 vascular plant species. Endemism is particularly high,
11916 ranging from <1% to 15% depending on the country (Chemonics International, 2001a, 2001b, 2001c,
11917 2001d, 2001e, 2001f; Nowak, Nowak, & Nobis, 2011) and especially high in the mountains of the
11918 Caucasus region. IUCN lists only 38 species as threatened (IUCN, 2017b), which very likely is strongly
11919 underestimated.

11920

11921 ***Drivers of change***

11922 Major threats to the diversity of vascular plants in the region are related to habitat destruction and
11923 degradation. Habitat loss is the primary cause of risk for 83% of endangered plant species (Silva et al.,
11924 2008). Particularly vulnerable are species with small distribution ranges (e.g. endemic species),
11925 specialized habitat and/or microhabitat requirements, narrow environmental tolerances and poor
11926 dispersal and competitive ability (Bilz et al., 2011b; IUCN, 2017b; Pauli et al., 2012). The intensification
11927 of agriculture is suggested to have the most severe impacts (**Table 3.11**) (Allan et al., 2014; Bilz et al.,
11928 2011b; Ministry of Natural Resources and Environment of the Russian Federation, 2015; Werger & van
11929 Staalduinen, 2012). Land-use intensification promotes generalist species while specialists are
11930 decreasing, leading to large-scale homogenization and loss of ecosystem functions (Gossner et al.,
11931 2016; Soliveres, Manning, et al., 2016; Soliveres, van der Plas, et al., 2016; van der Plas et al., 2016b).

11932 While the abandonment of intensive land-use regimes can lead to a recovery of grassland ecosystems
 11933 (Brinkert, Hölzel, Sidorova, & Kamp, 2015; Kämpf, Mathar, Kuzmin, Hölzel, & Kiehl, 2016), the
 11934 abandonment of traditional non-intensive land-use regimes, can also lead to the disappearance of
 11935 plant species with the growth of shrubland or forest, especially in mountain or steppe regions
 11936 (MacDonald et al., 2000; Mathar et al., 2015; Orlandi et al., 2016; Stöcklin, Bosshard, Klaus, Rudmann-
 11937 Maurer, & Fischer, 2007).

11938 Recreational human activities, invasive alien species, pollution (e.g. fertilizer, pesticides), habitat
 11939 fragmentation, habitat loss and overexploitation are also major threats (Bilz et al., 2011b; IUCN, 2017b;
 11940 Ministry of Natural Resources and Environment of the Russian Federation, 2015; Sekercioglu et al.,
 11941 2011; Silva et al., 2008). Islands with high proportions of endemic species are particularly vulnerable
 11942 to invasive alien species, especially the Macaronesian and the Mediterranean islands (Bruchmann,
 11943 2011; Celesti-Grapow et al., 2016; IUCN, 2017b; Silva et al., 2008). However, studies of the impact of
 11944 invasive alien species on the diversity of native species are largely missing across Europe and Central
 11945 Asia and statements on negative impacts often anecdotal (Künzi, Prati, Fischer, & Boch, 2015).

11946 Numerous vascular plant species are used for medicinal, ornamental and cultural purposes as well as
 11947 in traditional agriculture (IPBES, 2016b), in some cases causing overexploitation, i.e. East-
 11948 Mediterranean orchids used for salep production (Ghorbani, Gravendeel, Naghibi, & de Boer, 2014)

11949

11950 3.4.10 Bryophytes

11951 **Status and trends**

11952 Bryophytes are photosynthetic non-vascular plants that reproduce by spores. Despite the wide range
 11953 of substrates colonized by bryophytes as a group, many species are restricted to narrow ecological
 11954 niches with specific requirements concerning substrates and habitat persistence. Bryophytes
 11955 constitute an important component of vegetation, biodiversity and biomass in various ecosystems (e.g.
 11956 forest, wetland, mountain, tundra) and thereby make essential contributions to ecosystem functions
 11957 (e.g., soil stabilization, water retention, carbon sinks in peatlands).

11958 Across Europe and Central Asia, only 14 bryophyte species have been evaluated in the IUCN Red List
 11959 of Threatened Species (IUCN, 2017b). In Europe, nearly 2,000 bryophyte species occur (1,342 mosses,
 11960 494 liverworts and hornworts), representing around 10% of the worlds' bryophyte diversity. Fifty-one
 11961 per cent of these are endangered (693 moss and 242 liverwort and hornwort taxa; (Hodgetts, 2015).
 11962 A checklist for Eastern Europe and northern Asia (including Central Asia) includes 1,302 moss species
 11963 and complements the European checklist (Ignatov et al., 2006). Although globally and across Europe
 11964 and Central Asia, only very few bryophyte species have become extinct (Hallingbäck & Hodgetts, 2001),
 11965 locally or on the country scale many species are endangered or have even become extinct. However,
 11966 data on population trends are largely missing. Existing trend analyses are often based on survey data
 11967 from only small parts of the species range or on subjective assessments. This calls for further
 11968 investigation, especially in less surveyed countries.

11969

11970 **Drivers of change**

11971 As bryophytes are sensitive to changes, habitat destruction or degradation can eradicate local
 11972 bryophyte populations leading to decreasing range sizes (Hallingbäck & Hodgetts, 2001; Hodgetts,
 11973 2015; Maykop, 2012; Natcheva, Ganeva, & Spiridonov, 2006; Sabovljevit, Ganeva, Tsakiri, & Stefanut,
 11974 2001). For example, deforestation and the replacement of natural forests in combination with short
 11975 forestry rotation cycles causes a general lack of over-mature trees and deadwood. This can reduce
 11976 species richness and change community composition. In particular, habitat specialists, such as old-

- 11977 growth forest species, are then replaced by habitat generalists (Bardat & Aubert, 2007; Hallingbäck &
 11978 Hodgetts, 2001; Hofmeister et al., 2015; Paillet et al., 2010; Sabovljevit, Ganeva, Tsakiri, & Stefanut,
 11979 2001; Vanderpoorten, Engels, & Sotiaux, 2004).
- 11980 In non-forested ecosystems, bryophytes profit from non-intensive management regimes, habitat
 11981 heterogeneity and low competition (Bergamini, Peintinger, Schmid, & Urmi, 2001; Michal Hejcman et
 11982 al., 2010; Möls, Vellak, Vellak, & Ingerpuu, 2013; Müller et al., 2012; Takala, Kouki, & Tahvanainen,
 11983 2014; Zechmeister & Moser, 2001). Large-scale habitat conversion, peatland drainage, peat extraction
 11984 and land-use intensification over recent decades has led to habitat degradation and homogenization
 11985 at the landscape level. This has greatly reduced the extent of high-quality bryophyte habitats in line
 11986 with a drastic decline of bryophyte diversity and a persistent loss of bryophyte species, even after
 11987 applying different regeneration methods (Bergamini et al., 2009; Hallingbäck & Hodgetts, 2001;
 11988 Hedberg et al., 2012; Hodgetts, 1992; Sabovljevit, Ganeva, Tsakiri, & Stefanut, 2001; Schustov, 2015).
- 11989 In particular the application of fertilizer promotes competitive vascular plant and bryophyte species
 11990 that suppress species adapted to poor soil conditions (Alatalo, Jägerbrand, & Molau, 2015; Aude &
 11991 Ejrnæs, 2005; Bergamini & Pauli, 2001; Hallingbäck & Hodgetts, 2001; Heino et al., 2005; Hejcman et
 11992 al., 2010; Müller et al., 2012; Van Der Wal, Pearce, & Brooker, 2005; RVirtanen, Johnston, Crawley, &
 11993 Edwards, 2000).
- 11994 While the abandonment of intensive land-use regimes can lead to the recovery of grassland
 11995 ecosystems (Brinkert et al., 2015; Kämpf et al., 2016), the abandonment of traditional non-intensive
 11996 land-use regimes in grasslands, can also lead to the development of shrubland or forest ecosystems.
 11997 This can result in the loss of bryophyte diversity (Takala, Tahvanainen, & Kouki, 2012).
- 11998 Environmental pollution can have severe effects on bryophyte diversity, population sizes, regional
 11999 species pools and bryophyte performance, for example, SO₂ deposition (Bates & Farmer, 1992;
 12000 Hallingbäck & Hodgetts, 2001; Maykop, 2012; Sabovljevit et al., 2001; Zotz & Bader, 2009a; Zvereva &
 12001 Kozlov, 2011), high nitrogen deposition in large parts of Western and Central Europe (Armitage,
 12002 Britton, van der Wal, & Woodin, 2014; Bobbink et al., 2010; Field et al., 2014; Kumpula, Forbes,
 12003 Stammler, & Meschtyb, 2012; Phoenix et al., 2012), and various other pollutants (Sabovljevit et al.,
 12004 2001; Zvereva & Kozlov, 2011).
- 12005 Climate warming might lead to expanding distribution ranges of warmth-loving bryophyte species
 12006 northwards and to higher altitudes, but might also consistently negatively affect the abundance and
 12007 diversity of bryophytes with a particular future threat for oceanic bryophytes across Western and
 12008 Central Europe (Bergamini, Ungricht, & Hofmann, 2009; Delgado & Ederra, 2013; Hodd, Bourke, &
 12009 Skeffington, 2014; Zotz & Bader, 2009a). Warming experiments further suggest a future productivity
 12010 increase and shrub encroachment in tundra regions with consistently negative effects on abundance
 12011 and diversity of bryophytes (well established (Alatalo, Jägerbrand, & Molau, 2015; Cornelissen et al.,
 12012 2001; Elmendorf et al., 2012; Lang et al., 2012; Pajunen, Oksanen, & Virtanen, 2011; Risto Virtanen et
 12013 al., 2013; Walker et al., 2006)).
- 12014 Data on the impact of invasive species on bryophyte diversity is largely missing (but see (Hallingbäck
 12015 & Hodgetts, 2001)). The rapid colonization of sand dunes and heathlands in 21 European countries by
 12016 the invasive moss *Campylopus introflexus* suppresses other species (Essl & Lambdon, 2009; Essl,
 12017 Steinbauer, Dullinger, Mang, & Moser, 2013).
- 12018 A relatively minor threat is overexploitation (e.g. use bryophytes for commercial, scientific or private
 12019 purposes). However, collecting by bryologists has led to the extinction of one Portuguese species
 12020 (Hallingbäck & Hodgetts, 2001).
- 12021

12022 3.4.11 Lichens

12023 **Status and trends**

12024 Lichens are symbiotic associations between mycobiontic (fungi) and photobiontic (algae) partners.
 12025 They are an important component of vegetation and biodiversity in various ecosystems and contribute
 12026 to ecosystem functions (e.g. biogeochemical cycling, carbon storage, food-webs; (Cornelissen, Lang,
 12027 Soudzilovskaia, & During, 2007; Curtis et al., 2005; Edwards, Soos, & Ritcey, 1960; Gerson & Seaward,
 12028 1977; Pettersson, Ball, Renhorn, Esseen, & Sjöberg, 1995; Seaward, 2008). Despite the wide range of
 12029 substrates colonized by lichens as a group, many lichen species are restricted to narrow ecological
 12030 niches with specific requirements concerning substrate or habitat variables (Nash, 2008a)

12031 Global estimates for lichen species numbers range from 13,500 (Hawksworth, Kirk, Sutton, & Pegler,
 12032 1996) to 25,000 (Wirth & Hauck, 2013). In Europe (all 3 subregions, but excluding Russia) around 7,000
 12033 species occur (Feuerer, 2013), Russia harbors 3388 species (Andreev, 2010). Across Europe and Central
 12034 Asia, only five lichen species have been evaluated in the IUCN Red List of Threatened Species (IUCN,
 12035 2017b). National red lists across the region often comprise only parts of the occurring lichen flora and
 12036 a comprehensive supra-national red list, applying the IUCN criteria, is completely missing. However,
 12037 the proportion of nationally endangered or extinct species is generally high (Aptroot et al., 1998;
 12038 Cieslinski, Czyżewska, & Fabiszewski, 2003; Liška, Zdeněk, & Slavíková, 2012; Nascimbene, Nimis, &
 12039 Ravera, 2013; Randlane, Juriado, Suija, Lohmus, & Leppik, 2008; Scheidegger & Clerc, 2002; Serusiaux,
 12040 1989; Timdal, 2015; Türk & Hafellner, 1999; Westling, 2015; Wirth et al., 2011; Woods & Coppins,
 12041 2012; Zamin et al., 2010). Lichens were not considered in the Natura 2000 program and the Global
 12042 Strategy for Plant Conservation of the Convention on Biological Diversity (Nascimbene, Nimis, &
 12043 Ravera, 2013b). This indicates the general need to fill this gap in line with the 2020 Aichi Biodiversity
 12044 Targets.

12045 Knowledge on endemic lichen species is scarce. An attempt was made by the Arctic Council, listing 133
 12046 lichen species which were never found outside Panarctic countries. Of these, 61 lichen species only
 12047 occur in Europe and Central Asia (Kristinsson, Zhurbenko, & Steen Hansen, 2010). Moreover, 34 lichen
 12048 species were so far recorded only from the British Isles (Woods & Coppins, 2012) and 12 from the
 12049 Madeira archipelago (Carvalho, Figueira, & Jones, 2008). In addition, data on bryophyte population
 12050 trends are largely missing. Existing trend analyses are often based on survey data from only small parts
 12051 of the species range or on subjective assessments. This calls for the need of further investigation,
 12052 especially in less surveyed countries.

12053
 12054 **Drivers of change**

12055 Lichens are very sensitive to changes in their environment. Therefore, pollution, environmental, land-
 12056 use and climatic changes, and habitat destruction can eradicate local lichen populations leading to a
 12057 decline in range size. For example, deforestation and the replacement of natural forests with
 12058 plantations, in combination with short forestry rotation cycles, cause a general lack of over-mature
 12059 trees and deadwood, and lack of forest structure. This can lead to homogenous lichen communities
 12060 and the isolation of dispersal or establishment-limited species, reducing the species richness and the
 12061 genetic diversity of lichens (Cornelissen et al., 2001; Ellis, 2012, 2015; Hauck, Bruyn, & Leuschner, 2013;
 12062 Hofmeister et al., 2015; Nascimbene, Nimis, & Ravera, 2013; Paillet et al., 2010; Scheidegger & Werth,
 12063 2009; Wolseley, 1995). In non-forested ecosystems, lichens profit from non-intensive management
 12064 regimes, habitat heterogeneity and low competition. Large-scale conversion and land-use
 12065 intensification over recent decades has led to habitat degradation and homogenization at the
 12066 landscape level in line with a drastic decline of lichen diversity (Boch, Prati, Schöning, & Fischer, 2016;
 12067 Dengler et al., 2014b; Gossner et al., 2016; Hölzel, Haub, Ingelfinger, Otte, & Pilipenko, 2002b; Kamp

et al., 2011; Korotchenko & Peregrym, 2012; Mathar et al., 2015; Maykop, 2012; Shustov, 2015; Stofer et al., 2006; The Russian Academy of Sciences, 2014; Werger & van Staalduinen, 2012; Wirth et al., 2011; Wolseley, 1995). The abandonment of traditional non-intensive land-use regimes in grasslands is leading to the loss of soil-dwelling lichens (Hauck, 2009b; Leppik, Jüriado, Suija, & Liira, 2013).

Environmental pollution can have severe effects on lichen diversity, population sizes, regional species pools and lichen performance. For example, sulphate deposition eradicated the lichen diversity in large parts of Europe (Bates & Farmer, 1992; Gilbert, 1992; Hauck, 2009a; Hauck, Bruyn, & Leuschner, 2013b; Insarov & Insarova, 2013; Kirschbaum, Windisch, Vorbeck, & Hanewald, 2006; Maykop, 2012; Nash, 2008b; Purvis, 2015; Purvis et al., 2010; Sedelnikova, 1988; Zotz & Bader, 2009b). In addition, the high nitrogen deposition in large parts of Europe promotes nitrophytic species to the detriment of acidophytic ones (Hauck, 2010; Insarov, Moutchnik, & Insarova, 2010; Karelian research centre of the Russian Academy of Sciences, 2008; Liška et al., 2012; Lisowska, 2011; van Herk, 2001); increases the growth of competing species such as vascular plants; and suppresses soil-dwelling lichens (Armitage et al., 2014; Britton & Fisher, 2010; Field et al., 2014; PHOENIX et al., 2012).

Climate-warming might lead to expanding distribution ranges of warmth-loving lichen species northwards, but also might consistently negatively affect the abundance and diversity of lichens (Aptroot & van Herk, 2007; Davydov, Insarov, & Sundetpaev, 2013; Insarov & Schroeter, 2002; Zotz & Bader, 2009a), for example by productivity increase and shrub encroachment in tundra regions (Alatalo, Jägerbrand, & Čuchta, 2015; Cornelissen et al., 2001; Elmendorf et al., 2012; Lang et al., 2012; Pajunen et al., 2011; Virtanen et al., 2013; Walker et al., 2006) or the replacement of lichen-rich forests (Andreev & Himelbrant, 2014).

Data on the impact of invasive species on lichen diversity is largely missing. However, the invasive moss *Campylopus introflexus* is causing a decline of lichen abundance and diversity in sand dunes and heathlands of 21 European countries (Biermann & Daniels, 1997; Essl & Lambdon, 2009; Hassel & Soderstrom, 2005; Ketner-Oostra & Sýkora, 2004; Sparrius & Kooijman, 2011). Moreover, the replacement of native forests by stands of non-native tree species negatively affects lichen diversity, for example *Robinia pseudoacacia* stands (Juri Nascimbene et al., 2015). The invasive box tree moth (*Cydalis perspectalis*) is depleting natural European box (*Buxus sempervirens*) forests in the Caucasus region (Russian Forest Protection Centre, n.d.). As many rare epiphyllous lichen species are growing on the evergreen leaves of the European box (Vězda, 1983), this severely threatens their populations. In addition, epidemic tree pests, such as the current large-scale European ash borer, a species of jewel beetle (*Agrilus planipennis*) across Europe threatens many lichen species, as ash is the host tree of a large number of specialized and threatened epiphytic lichens (Ellis et al., 2014; Ellis, Coppins, & Hollingsworth, 2012; Jönsson & Thor, 2012; Löhmus & Runnel, 2014; Marmor, Randlane, Jüriado, & Saag, 2017; Rigling et al., 2016).

3.4.12 Fungi

Fungi contribute a large share of terrestrial species richness and are key players in ecosystem processes (Peay, Kennedy, & Talbot, 2016). Estimates of the global number of fungal species range between 2.2 to 3.8 million, of which 120,000 currently are described and accepted species. Fungi are, for practical reasons, often divided into macro- and microfungi. The overwhelming number are microfungi, i.e. species without sporocarps like molds and yeast or sporocarps smaller than 1 mm. These are not dealt with here, similar to microorganisms, due to insufficient knowledge of their distribution and ecology and lack of IUCN Red List assessments. Macrofungi (phyla Basidiomycota and Ascomycota), have visible sporocarps (> 1mm), constitute about 30% of known fungi, and are undergoing extinction risk

assessments according to the categories and criteria of IUCN (Dahlberg & Mueller, 2011). Due to their largely hidden mycelial nature and frequently sporadic and short-lived sporocarps, fungi are more poorly understood and appreciated than plants and animals. Hence, fungi have largely been invisible to the conservation community and policymakers and often overlooked in national and international nature conservation actions. During the last decades, however, the knowledge has significantly increased of the status and trends for fungi, how human activities affect fungal diversity and how to counteract threats (Dahlberg & Mueller, 2011; Heilmann-Clausen et al., 2015).

Status and trends

Macrofungal checklists exist for most European countries and for most Russian regions, but have varying degrees of completeness (Senn-irlet, Heilmann-Clausen, Genney, & Dahlberg, 2007). However, there is no combined checklist for Europa or Central Asia. Species richness of macrofungi in Europe has been estimated to be at least 15.000 (Dahlberg, Genney, & Heilmann-Clausen, 2010) and 8000 in Russia (Kovalenko et al., 2005, Svetasheva, pers. com). The total species richness of fungi in Europe (Western and Central Europe including Turkey but excluding Isarel), is considered to exceed 75 000 – 100 000 (Senn-irlet et al., 2007). In 2005, the number of known fungi in Russia was 11.000 and the total number of fungi exceeded 25 000 (Kovalenko et al., 2005). Only twenty-five macrofungal species have been globally assessed for extinction risk according to the IUCN Red List categories and criteria (IUCN, 2017c), but the list is growing thanks to a dedicated Red List Initiative for fungi³⁰. Of these, 13 species are distributed in Europe and Central Asia, of which 10 are distributed in geographic Europe (including geographically European Russia west of the Ural mountains, but not Turkey and Israel) and three in the whole region. Ten of the 13 species are threatened (one EN and nine VU). At least 33 national fungal Red Lists exist in Western and Central Europe, which are widely used for management and conservation actions across Europe (Dahlberg et al., 2010). Similarly, Russia has a national Red Data Book (2008) with 24 listed species of fungi and in addition, 82 of the 85 regions in Russia have regional Red Data Books, which in total include 700 macrofungal species (Svetasheva, 2017). In total, 5500 macrofungal species are red-listed in at least one European country, of which at least 1664 species are considered to qualify as red-listed also at the European level (Dahlberg et al., 2010). In European countries with comprehensive fungal red-list assessment, about 20 % of known species are red-listed and 10% categorized as threatened (e.g. in Finland, Germany, the Netherlands, Norway and Sweden (Tingstad, Gjerde, Dahlberg, & Grytnes, 2017)). These figures imply that about 5% of the European and Central Asian macrofungi would be threatened with extinction (categories Vulnerable, Endangered and Critically Endangered) if such a red-list assessment would take place.

The lack of fungi in global and European Red Lists have hindered the inclusion of fungi in international conservation agreements such as in the Annex II, IV and V of the European Union Habitat Directive. Forest ecosystems are by far the most species-rich habitats for macrofungi. Natural and extensively used European and Asian forests provided different conditions and dynamics to fungal diversity than the managed forests of today (Nordén et al., 2014). Accordingly, about 75% of the nationally and globally threatened macrofungi are dependent on woodlands, mainly as associates with coarse dead wood or as ectomycorrhizal fungi with particular habitat requirements, and restricted to old-growth forests conditions. The persistence of threatened woodland fungi is determined by a combination of stand level factors together with factors related to the surrounding landscape matrix such as proximity and extent of intensively managed forests and old growth forest habitats (Jönsson et al. 2017). Other habitats of large importance for fungal conservation are semi-natural grassland and natural steppe, containing some of the most threatened species, and totalling about 10-20% of national and globally

³⁰ <http://iucn.ekoo.se/en/iucn/welcome>

threatened species. These habitats have dramatically declined throughout Europe and Asia due to conversion to arable crops, tree plantations and scrublands (Emanuelsson, 2010). Many grassland fungal species have evolved in nutrient poor and stable conditions, and disappear when artificial fertilizers are applied and decline due to atmospheric deposition of nitrogen (Arnolds, 2001). Furthermore, some types of wetland, e.g. mires and alkaline fens, are important habitats for about 5% of nationally threatened fungi in Europe. These species are sensitive to any change of hydrological regime and eutrophication (Fraiture & Otto, 2015; Svetasheva, 2015). Alkaline fens are of high conservation priority due to extensive past drainage (Šefferová Stanová, Šeffer, & Janák, 2008)

There is strong evidence of a decline of ectomycorrhizal fungi due to eutrophication and linked to the level of nitrogen deposition in Europe (e.g. Arnolds, 2010; Dahlberg et al., 2010).

Drivers of change

The major threats to threatened macrofungi in the region are (i) habitat decline and degradation due to intensified land use of forests, semi-natural grasslands and steppe, (ii) land-use change of forests, semi-natural grasslands and steppe, followed by (iii) eutrophication and (iv) effects of invasive pathogens on native tree species (Senn-Erlet et al. 2007; Dahlberg et al 2010). Climate change is an emergent threat likely to directly and indirectly affect fungal diversity (Heilmann-Clausen et al., 2015).

The invasion of the alien fungal pathogens Dutch elm disease and ash decline have been devastating for the distribution of elm and ash in Europe and caused declines in fungal diversity associated with these trees (Brasier & Buck, 2001; Landolt, Gross, Holdenrieder, & Pautasso, 2016). Ecological impacts of alien invasive pathogens are projected to continue to increase in the future due to trade and climate (Santini et al., 2013).

Long-term Pan-European studies imply climate to drive community changes and range expansion, so far manifested by increased fungal fruiting periods (e.g. Kausrud et al., 2012). Forest management has a potential to compensate negative effects of climate change by increasing set-aside forests to prevent the decline of old-forest species under climate change (Mair et al., 2017). Climate is also affecting the distribution of invasive tree pathogens native to Europe that may become negative for native tree species, e.g. the northerly range expansion of the pathogen *Diplodia* to Scots pine (Oliva et al., 2013). Furthermore, climatic change increasingly fosters alien tree species, e.g. *Acer negundo* and *Robinia pseudacacia* to invade forests and grasslands, thereby changing fungal communities and driving threatened species out of these habitats (Kleinbauer, Dullinger, Peterseil, & Essl, 2010).

Table 3.11. Summary of past and current trends in the biodiversity of different taxa in Europe and Central Asia and of the attribution of these trends to direct drivers of change (3.4.2-3.4.12). WE, CE and EE denote Western, Central and Eastern Europe, CA denotes Central Asia, and ECA denotes Europe and Central Asia.

TRENDS AND IMPACTS		<div><div>● high impact</div><div>● moderate impact</div><div>● no or marginal impact</div></div>																																												
Taxon		General trend			current			Climate change						Land use change						Pollution			current			Overexploitation						IAS			current											
		past						past						past						past						past						past														
		ECA	WE	CE	EE	CA	ECA	WE	CE	EE	CA	ECA	WE	CE	EE	CA	ECA	WE	CE	EE	CA	ECA	WE	CE	EE	CA	ECA	WE	CE	EE	CA	ECA	WE	CE	EE	CA	ECA	WE	CE	EE	CA					
Mammals		↘	↘	↘	↘		↘	↘	↘	↘		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		
Birds		↘	↘	↘	↘		↘	↘	↘	↘		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
Reptiles		↗	↗	↗	↗		↗	↗	↗	↗		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
Amphibians		↘	↘	↘	↘		↘	↘	↘	↘		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
Marine fishes	Arctic Ocean	↔					↔					●					●					●				●					●				●				●							
	North East Atlantic pelag./demer.	↔,↘					↔,↗					●					●					●				●					●				●				●							
	Mediterranean	↘					↘					●					●					●				●					●				●				●							
	Black Sea	↘					↔					●					●					●				●					●				●				●							
	Caspian Sea	↘					↕					●					●					●				●					●				●				●							
	North West Pacific pelag./demer.	↘,?					↗,?					?					?					?				?					?				?				?							
Freshwater fishes												●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
Terrestrial invertebrates		↘	↘	↘	↘		↘	↘	↘	↘		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Freshwater invertebrates		↘	↘	↘	↘		↘	↘	↘	↘		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Vascular plants		↘	↘	↘	↘		↘	↘	↘	↘		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Bryophytes		↘	↘	↘	↘							●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Lichens		↘	↘	↘	↘		↘	↘	↘	↘		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

12196 3.4.13 Progress towards Multilateral Environmental Agreements for species 12197 conservation

12198 ***European Union Biodiversity Strategy***

12199 Target 1 of the European Union Biodiversity Strategy calls for halting the “deterioration in the status
12200 of all species and habitats covered by European Union nature legislation (Habitats and Birds
12201 Directives), and achieving a significant and measurable improvement in their status so that, by 2020,
12202 compared with current assessments:

12203 (a) 100% more habitat assessments and 50% more species assessments under the Habitats Directive
12204 show [a favourable or] an improved conservation status [with respect to the last reporting period at
12205 the time of adoption of the European Union Biodiversity Strategy to 2020: that is the 2001-2006
12206 reporting period];

12207 (b) 50% more species assessments under the Birds Directive [with respect to 2001-2006 as with the
12208 Habitat Directive] show a secure or improved status”.

12209 For the Birds Directive, the baseline was 52% of the 447 species naturally occurring in the European
12210 Union having a secure status. In the last reporting period (2007-2012), this figure was unchanged, and
12211 8.5% were assessed as threatened but improving. Therefore, there is still a 17.5% shortfall in the
12212 percentage of species that should be secure or improving with respect to 2001, for the European Union
12213 target to be met (EEA, 2015).

12214 An additional 17% of the bird species naturally occurring in the European Union were assessed as
12215 threatened, and 15% were assessed as near-threatened or declining or having depleted populations.
12216 The remaining 16% of the species had unknown population status. There are no discernible geographic
12217 patterns in these status and trends, but there are ecosystem-level and taxonomic differences:
12218 grassland, heathland and coastal species, petrels, shearwaters and galliforms have a higher proportion
12219 of threatened, near-threatened and declining species than other groups (EEA, 2014) (Section 3.4.2).
12220 Moreover, short-term declining trends are more prevalent among bird species in all marine
12221 ecosystems than species in other ecosystems (EEA, 2015).

12222 For the Habitat Directive, the baseline in 2001 initially assessed 15% of species as being favourable but,
12223 when further data became available, a retrospective analysis corrected this baseline to 23%. This
12224 means that, for the European Union biodiversity target 1 to be met, 35% of species assessments should
12225 be favourable or improving by 2020 (150% of 23%). Overall, 118 monitored species of plants and
12226 animals in the European Union have unfavourable conservation status but improving trends, 572 have
12227 unfavourable conservation status and deteriorating trends and 905 have unfavourable status and
12228 stable trends (EEA, 2015).

12229 Overall, in the 2007-2012 reporting period, 23% of the assessment were still favourable, 60% were
12230 unfavourable and 17% had unknown conservation status. Looking at trends of unfavourable species,
12231 4% of the species assessments were unfavourable but improving 20% were unfavourable stable, 21%
12232 unfavourable and deteriorating and 14% unfavourable with unknown trends. There is therefore a 8%
12233 shortfall in species that should be favourable or improving with respect to 2001 for the European Union
12234 target to be met (EEA, 2015).

12235 The terrestrial and freshwater species faring worst in terms of status and trends are slightly more
12236 prevalent in the Pannonian and Steppic biogeographic regions of Central Europe (Hungary, part of
12237 Slovakia and Czech Republic, part of Romania) and the Continental, Atlantic and Mediterranean
12238 biogeographic regions (all of Western and Central Europe part of European Union , except Hungary,
12239 Scandinavia, and the Baltic Countries) (EEA, 2015). The Macaronesian islands stand out by having the

12240 highest number of unfavourable but improving population assessments (12.1%) followed by Boreal
12241 and Atlantic regions (9% and 6.8% of assessment, respectively).

12242 Assessing progress towards the European Union Biodiversity Strategy for marine species is marred by
12243 uncertainty in status and trends (Section 3.4.6), over half of the assessments having unknown trends.
12244 The exception is the Baltic Marine Bioregion, for which all trends are considered known and 60% are
12245 improving.

12246 The main drivers of recent past population declines across all realms are agriculture (use of biocides
12247 and chemicals affected 73% of assessed populations, intensification 42%, modification of cultivation
12248 practices 36%); reduction of habitat connectivity (55%); pollution of surface waters (56%); invasive
12249 alien species (46%); human induced changes in hydraulic conditions (43%); and forestry (removal of
12250 dead trees (39%), clearance (38%), logging of natural and plantation forests (38%) (EEA, 2015).

12251 Across all species and realms, 99% of the favourable assessments for species in the 2007–2012 period
12252 were already favourable in the 2001–2006 period; this means that only 0.4% (11 assessments) truly
12253 changed from unfavourable to favourable (EEA, 2015). At this rate, European Union Biodiversity target
12254 1 will not be met for species.

12255

12256 ***Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)***

12257 The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Strategic
12258 Vision for 2020 includes Goal 3 “Contribute to significantly reducing the rate of biodiversity loss and to
12259 achieving relevant globally agreed goals and targets by ensuring that CITES and other multilateral
12260 instruments and processes are coherent and mutually supportive”. CITES is legally binding and
12261 regulates trade in live plants and animals, their parts and products derived from them. Species subject
12262 to regulations are listed in three Appendices³¹. 529 species in Appendices of CITES occur in Europe and
12263 Central Asia. Of the 334 species with known population trends, 74% are declining (**Table 3.12**).
12264 Importantly, 206 of these species continue to be threatened by direct large-scale overexploitation and
12265 23 of these are endemic of Europe and Central Asia. It was not possible to track the trade flows of
12266 these species, however 17 of these are endemic, and therefore their unsustainable harvest occurs
12267 within the region. These are nearly 50% of the 40 endemic species listed in CITES annexes. This suggest
12268 that countries in Europe and Central Asia are moving away from achieving the CITES vision for 2020³².

12269

12270 **Table 3.12: Trends in CITES-listed species in Europe and Central Asia. Data obtained from analysing**
12271 **IUCN assessment data retrieved in September 2017 (IUCN, 2017c). Species lists for CITES were**
12272 **obtained by querying <https://www.speciesplus.net>**

	<i>Increasing</i>	<i>Stable</i>	<i>Declining</i>	<i>Unknown</i>
<i>Appendix I</i>	11	6	23	7

³¹ Those in Annex I are particularly threatened and their commercial trade is banned; those in Annex II are those for which permits are needed for their international trade; those in Annex III are species included at the request of a Party that already regulates trade in the species and that needs the cooperation of other countries to prevent unsustainable or illegal exploitation; these species also require permits. Some species, including the gray wolf, are in Annex I in some countries and in Annex II in other.

³² Number obtained by intersecting IUCN data on direct threats to species with population trends from the IUCN Red List Database version 2017.1 (IUCN, 2017c) on the subset of species listed in the CITES Annexes and whose range overlap with the Europe and Central Asia region. The list of threats considered where: Hunting & collecting terrestrial animals (threat code 5.1.1: target species, threat code 5.1.4: motivation unknown or unrecorded), Gathering terrestrial plants (threat code 5.2.1: target species, threat code 5.2.4: motivation unknown or unrecorded), Logging and wood harvesting (threat code 5.3.2: target species, large scale harvest, threat code 5.3.5: motivation unknown or unrecorded), Fishing & harvesting aquatic resources (threat code 5.4.2: target species, large scale harvest; threat code 5.4.6: motivation unknown or unrecorded).

Appendix II	15	50	216	183
Appendix I and II	0	3	0	1
Appendix III	1	1	8	4

Aichi Biodiversity Targets

Here we report on progress towards Aichi Biodiversity Targets 12 and 13, the only ones exclusively focusing on species. Aichi Biodiversity Target 12 calls for halting species extinctions and improving the conservation status of threatened species by 2020. The indicators identified to monitor progress towards this target are the Red List Index and the Living Planet Index, although any credible measure of population trends or conservation status can be used to assess progress at national or regional scale. The Red List Index for Europe and Central Asia is declining and the Living Planet Index, only available for selected terrestrial vertebrates, is slightly declining since 2004 (**Figure 3.54**). Our independent review of the conservation status of all reported taxa in Europe and Central Asia (**Table 3.11**) confirms the trends reported by these two indicators, which, unlike our review, are taxonomically biased towards vertebrates and selected plant groups. There are notable exceptions to these general trends. For instance, the conservation status of large mammalian carnivores and bird species that have benefited from conservation attention has improved in the last two decades (Paragraphs 3.4.2, 3.4.3). Nevertheless, 44.4 % of the species extant in Europe and Central Asia with known population trends in the IUCN Red List are declining (over a total of 5244 species extant in the region and with known trends of July 2017), 50.2% are stable and only 5.3% are increasing.

For marine species these figures are 436 decreasing, 410 stable, and 59 increasing, respectively, i.e. 48.2%, 45.3% and 6.5%; for terrestrial species 42%, 51.7%, and 6.3%; and for freshwater species 50.2%, 7.3% and 42.5%. Note, however, that population trends are assessed throughout a species range which could extend outside the region³³. These results combined suggest that, despite decelerating trends in extinction risk, countries in Europe and Central Asia are not on track to meet Aichi Biodiversity Target 12.

Aichi Biodiversity Target 13 calls for the genetic diversity of cultivated plants and farmed and domesticated animals and of wild relatives to be maintained by 2020. The indicator chosen for animals is the trend in conservation status of domestic breeds. In 2005, 2,228 domesticated breeds of mammals and 976 domesticated breeds of birds were recorded for Europe and the Caucasus by the Food and Agriculture Organization of the United Nations. Of these, a minimum of 50.7% and a maximum of 74.6% were either extinct or at risk of extinction, depending on how many species with unknown trends were assumed to be at risk. In 2015 a further 540 mammal breeds and 426 avian breeds were listed in Europe and Central Asia. The minimum number of breeds extinct or at risk had decreased to 45.3% but the maximum number increased to 80.4% or, put in a different way, the number of certainly safe breeds decreased by 5.8% in 10 years (FAO, 2007, 2015)

For plant species, the indicators are more complex. A common proxy is the number of crop varieties grown in a country or region. However, this is not always correlated with genetic diversity. While genetic erosion was reported in several countries in Europe and Central Asia, a recent meta-analysis found that, overall, there appears to have been no substantial reduction in genetic diversity as a result of crop breeding in the twentieth century (van de Wouw, van Hintum, Kik, van Treuren, & Visser, 2010). In addition, the threat of hybridization of ornamental species with domestic congeners seems not to be high (Klonner et al., 2017). On the other hand, several local crop varieties were lost due to replacement by higher-yielding crops, for instance all local maize and wheat varieties in Albania (FAO,

³³ Data obtained by analyzing population trends and geographic range from IUCN

2010). As the latest FAO report on genetic diversity of cultivated plants and wild relatives puts it, „convincing evidence may be lacking for genetic erosion in farmer varieties on the one hand and released varieties on the other hand, far greater consensus exists on the occurrence of genetic erosion as a result of the total shift from traditional production systems depending on farmer varieties to modern production systems depending on released varieties“ (FAO, 2010). Based on these conclusions and those of the FAO reports on domestic animal breeds it appears that, despite efforts to protect rare domestic breeds and germplasms of cultivated plant varieties, Aichi Biodiversity Target 13 is not on track to be met for Europe and Central Asia.

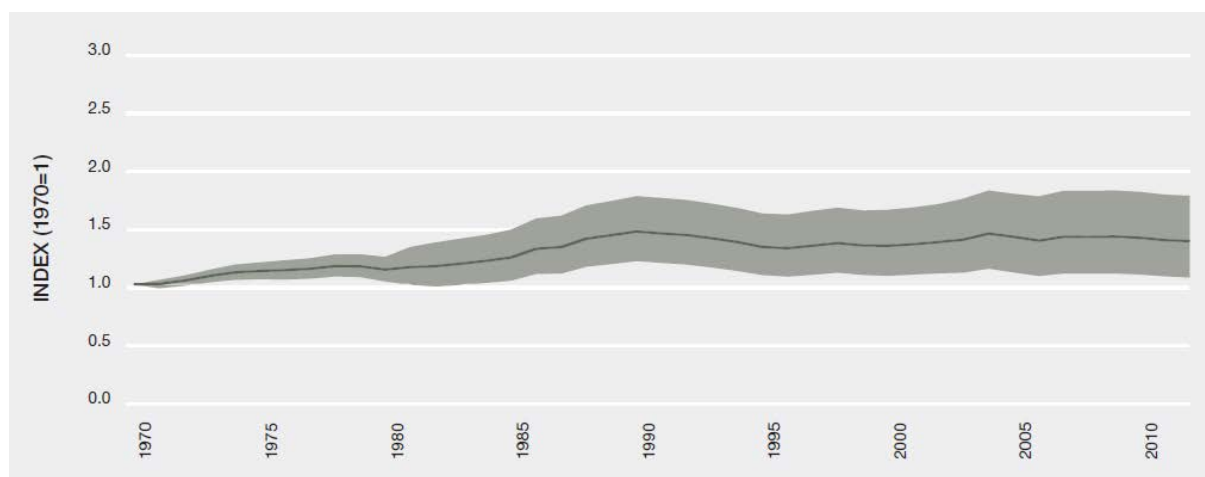


Figure 3.54 Trends of the Living Planet Index for Europe and Central Asia for terrestrial vertebrates. The Living Planet Index is the geometric mean of the rate of change in population abundance of vertebrate species populations since 1970 (LPI, 2016). The Living Plant Index is based on the population abundance of 2,707 populations of 392 species monitored within Europe and Central Asia between 1970 and 2012. The white line shows the index values and the shaded areas represent the 95 per cent confidence limits surrounding the trend. The trend indicates a 10% increase (range: -17 to +45 per cent) between 1970 and 2012 and a steady decline since 2004.

Convention on Migratory Species

The Convention on Conservation of Migratory Species of Wild Animals is more commonly known as the Convention on Migratory Species. Its Strategic Plan for Migratory Species (2015-2023), mirrors the Strategic Plan for Biodiversity 2011-2020. Its target 8 is, “[by 2023] the conservation status of all migratory species, especially threatened species, has considerably improved throughout their range”.

To report on progress towards this target for Europe and Central Asia, we intersected information from the IUCN Red List database, reporting global population trends for over 12,000 species in Europe and Central Asia, with the list of species in Appendices I³⁴ and II³⁵ of the CMS.

³⁴ Appendix I comprises migratory species that have been assessed as being in danger of extinction throughout all or a significant portion of their range. (source: <http://www.cms.int/en/page/appendix-i-ii-cms>)

Parties that are a Range State to a migratory species listed in Appendix I shall endeavour to strictly protect them by: prohibiting the taking of such species, with very restricted scope for exceptions; conserving and where appropriate restoring their habitats; preventing, removing or mitigating obstacles to their migration and controlling other factors that might endanger them.

³⁵ Appendix II covers migratory species that have an unfavourable conservation status and that require international agreements for their conservation and management, as well as those that have a conservation status which would significantly benefit from the international cooperation that could be achieved by an international agreement. The Convention encourages the Range States to species listed on Appendix II to conclude global or regional Agreements for the

There are 371 migratory bird species listed in the annexes of the Convention occurring in Europe and Central Asia. 150 of them have declining trends, 111 are stable, 67 increasing and 43 have unknown trends. Among the long-distance migrants, most engage in various Afro-Palearctic flyways. The majority of these species have long-term population declines, especially over the period 1970-1990, in particular those that winter in open savannas and breed on agricultural land (Vickery et al., 2014). More recently, Sahelian-wintering birds have shown some sign of recovery, whereas birds wintering in less arid parts of sub-Saharan Africa have shown a continued decline (Vickery et al., 2014).

Migrating ungulates have not fared better. Six out of eight have declining trends, including the saiga antelope which has twice suffered population collapses since the early 1990s, due to hunting and infectious diseases (Section 3.4.3). Of the 42 migratory bat species in Europe and Central Asia, 15 are declining, nine are stable, one is improving and 17 have unknown trends.

Among marine species listed in the appendices of the Convention on Migratory Species, all three sea-turtles in Europe and Central Asia - loggerhead, green and leatherback - have declining population trends. Twenty-three out of 27 cetaceans have unknown trends. Of the remaining four, three are increasing (blue, humpback and bowhead whale) and one, the Indo-Pacific humpback dolphin, is declining.

Twelve of 13 migratory sharks and rays have overall population declines, while the great white shark has unknown trends in Europe and Central Asia.

The only bony fishes listed in the Convention appendices from Europe and Central Asia are 14 sturgeon fishes, of which 13 are declining, while the Syr darya shovelnose sturgeon has unknown trends. A 15th species of the same family occurring in Europe and Central Asia, the Siberian sturgeon *Acipenser baerii*, is not listed by the Convention despite being migratory, and is also declining. There are no migratory invertebrates listed in the Convention appendices.

Overall, these results show that Europe and Central Asia countries are moving away from achieving Convention on Migratory Species targets (Table 3.13).

Table 3.13: Trends in species listed in appendices of the Convention on Migratory Species in Europe and Central Asia. Data obtained from analysing IUCN assessment data retrieved in September 2017 (IUCN, 2017c). Species lists for the Convention were obtained by querying <https://www.speciesplus.net>.

	<i>Increasing</i>	<i>Stable</i>	<i>Declining</i>	<i>Unknown</i>
<i>Appendix I</i>	5	0	13	4
<i>Appendix II</i>	64	118	158	76
<i>Appendix I and II</i>	5	4	30	7

conservation and management of individual species or groups of related species. (source: <http://www.cms.int/en/page/appendix-i-ii-cms>)

3.5 Future dynamics of biodiversity and ecosystems

3.5.1 Terrestrial systems

3.5.1.1 Species distribution and conservation status

Short term projections of the impact of climate change on plants, mammals and birds to 2020 indicate widespread contractions in suitable climatic ranges spanning from 10% to 55% depending on climate scenario and taxonomic group considered (Casazza et al., 2014; Wilfried Thuiller et al., 2011). Extrapolations of trends in farmland bird abundance to 2020 assuming business-as-usual socio-economic trends and full implementation of the Common Agricultural Policy in the European Union also show overall declines across the region, as well as national declines for 15 out of 26 countries considered (Scholefield et al., 2011).

Few studies investigated projections for a period relevant to the lifespan of the Sustainable Development Goals (2030). Disaggregated results of species richness intactness (ratio of species native to a pristine community extant in a given location) of plant and animals for the region from Newbold et al. (2015), report an 8% decline by 2035 under two alternative scenarios of land use, compatible with relative concentration pathways scenarios IMAGE 2.6 (W/m^2 of radiating forcing), and AIM 6.0 (W/m^2). For 2030, Verboom et al. (2007) found a 4% decline in relative richness under the 4 Special Report on Emissions Scenarios (SRES).

Combined effects of land-use and climate change under business-as-usual scenarios for the second part of the 21st century, are projected to cause widespread range shift and contraction and local population declines across animal and plant species. On average, ranges of mammalian carnivore and ungulate species in Europe (excluding the Russian Federation) are expected to contract by 8% assuming that all species can adapt locally to climate change (therefore declining exclusively due to habitat loss); by 15% if they are allowed to track suitable climatic conditions by dispersing at their maximum physiological dispersal; or by 24% if it is assumed that they cannot disperse (Rondinini and Visconti, 2015). Under these conditions, range shifts and contractions are predicted by 2050 for two-thirds of European breeding birds (Barbet-Massin, Thuiller, & Jiguet, 2012), for tree species in France (Cheaib et al., 2012) and for alpine plants in Europe with about 50% average reduction in range size by 2100 (Dullinger et al., 2012; Engler et al., 2011a).

On average, across all plant and animal groups, local richness and mean species abundance are projected to continue to decline throughout the region, under business-as-usual socio-economic scenarios (**Figure 3.55, Figure 3.56**). Declines are widespread throughout Europe and Central Asia with the exception of the arid parts of Central Asia and the Russian Federation which are less suitable to agricultural expansions and therefore are not projected to incur further habitat loss (**Figure 3.55**).

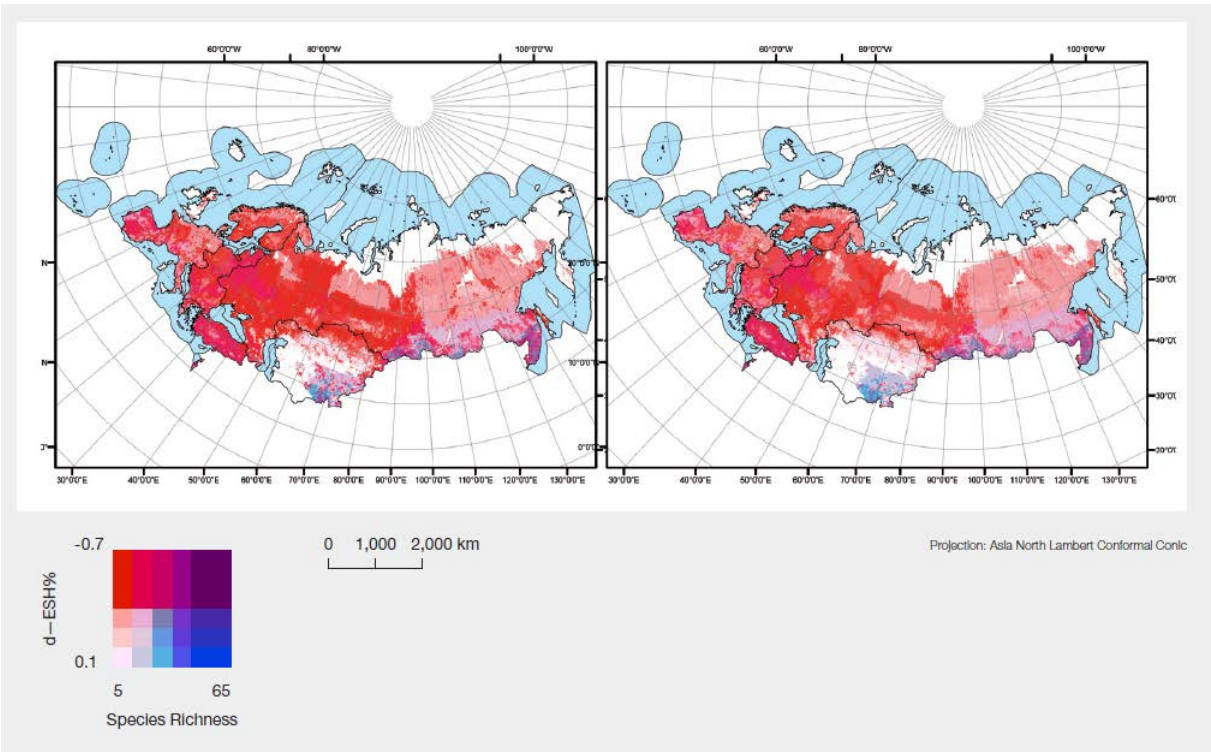


Figure 3.55: Bivariate map showing spatial pattern in species richness (shades of blue) and local mean percentage changes in extent of suitable habitat between 2010 and 2050 (shades of red, d-ESH in the caption) for all mammalian terrestrial carnivore and ungulate species under a business-as-usual scenario, with land use and climate change and assuming that species cannot disperse to track climate change (A) and species can disperse one mean dispersal distance per generation (B), source: Visconti et al. (2016).

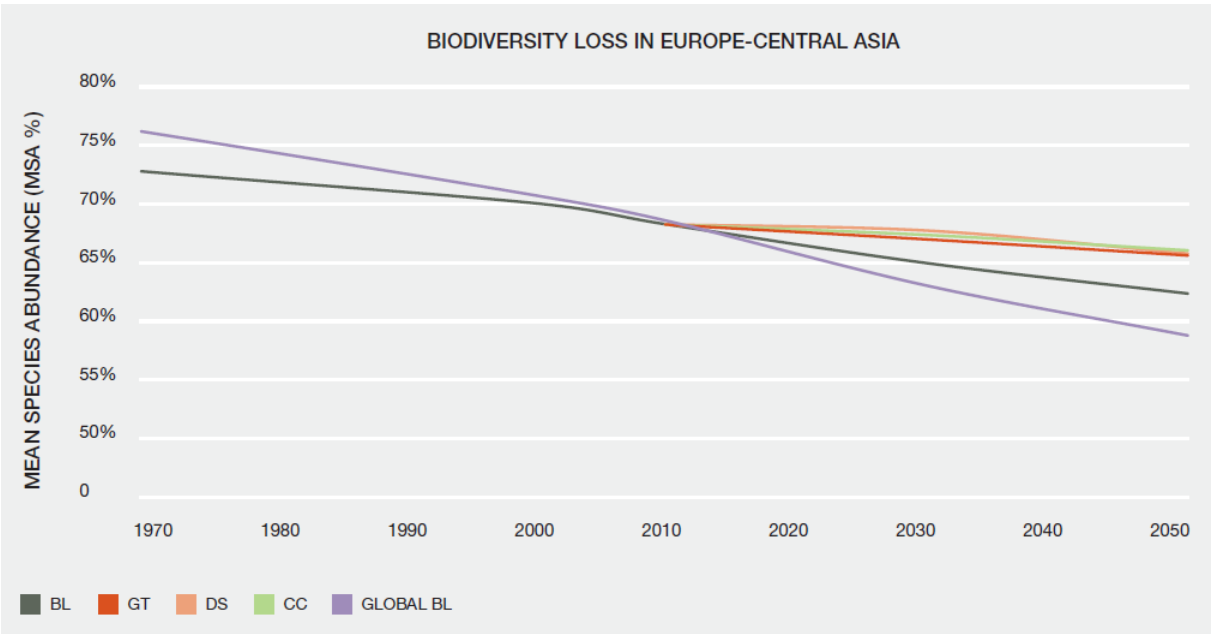


Figure 3.56: Trends in mean species abundance across animal and plant groups for four future scenarios for Europe and Central Asia and the world. BL: baseline; GT: global technology, DS: decentralized solutions, CC: consumption change. Storylines for each scenarios are in Chapter 5 (PBL, 2014).

12418 Extinction risk prognoses assessed through IUCN Red List criteria, are projected to deteriorate for one
 12419 to eight species of large mammals in Western and Central Europe (out of 27 investigated), depending
 12420 on the assumption made with regards to ability to track climate change (Rondinini & Visconti, 2015;
 12421 Visconti et al., 2016).

12422 Overall, these results provide evidence that, under business-as-usual socio-economic trends and in
 12423 absence of new policies for conservation of biodiversity and ecosystem services, the Convention on
 12424 Biological Diversity vision to halt the loss of biodiversity, will not be met by 2050 and beyond for Europe
 12425 and Central Asia. Normative scenarios that aim to meet these targets have been produced (Alkemade
 12426 et al., 2010; PBL, 2012, 2014). These studies showed that policies to mitigate climate change that
 12427 involve replacing intensive forestry with reduced-impact logging, and increasing yields to spare land
 12428 from cultivation, can together stem biodiversity losses expected under baseline patterns of
 12429 consumption and production (see also Chapter 5 on normative scenarios designed to meet biodiversity
 12430 goals).

12431

12432 3.5.1.2 Community composition

12433 Local taxonomic richness of native species (alpha diversity) across plants, fungi and animal taxa in the
 12434 terrestrial environment is expected to decline across all of Europe and Central Asia under business-as-
 12435 usual scenarios of habitat loss (ignoring other drivers of change), except for boreal forests in
 12436 Fennoscandia and Russia and for the arid regions of central Asia which are not projected to incur
 12437 agricultural expansion (Newbold et al., 2015). Similar richness patterns are found in freshwater
 12438 environments (below).

12439 Species range shift, ecological filtering through loss of native vegetation, and the introduction of new
 12440 species are projected to result in increased temporal turnover of species across most terrestrial
 12441 ecosystems (Barbet-Massin & Jetz, 2014; Newbold et al., 2015; Verboom et al., 2007). Similarly, local
 12442 functional diversity is also expected to increase, at least for birds across all subregions of Europe and
 12443 Central Asia, as a result of climate-driven range shifts (Barbet-Massin & Jetz, 2014). Climate-driven
 12444 range shifts, and species introductions are likely to lead to declines in beta (i.e. between-site) diversity
 12445 across the region, with resulting spatial biotic homogenization. For instance, beta taxonomic diversity
 12446 of plant species in the French Alps is expected to decline by 10-23% by 2050, depending on the climatic
 12447 model applied (Thuiller et al., 2014). Beta phylogenetic diversity in Europe for birds and mammals is
 12448 expected to decrease by 32% and 30% by 2080 under BAU socio-economic scenarios, as a consequence
 12449 of climate-induced range shifts, expansions and contractions (Thuiller et al., 2011).

12450

12451 3.5.1.3 Ecosystem extent, function and structure

12452 Within Europe and Central Asia, the extent of coniferous forests is expected to be maintained or even
 12453 increase. Meanwhile, tundra, other Alpine ecosystems, Mediterranean ecosystems, and broad-leaved
 12454 and mixed forests are expected to substantially contract, because of climate and land-use change
 12455 (Benito Garzon et al., 2008; Lehsten et al., 2015; Verboom et al., 2007). Increasing water deficit
 12456 (aridification) may lead to range contractions of some tree species, especially those with limited
 12457 migration ability, such as European beech (Saltr , Duputi , Gauch rel, & Chuine, 2015). A rapid upward
 12458 shift of mountain vegetation belts by ca. 500 m and treeline positions of ca. 2500 m a. s. l. by the end
 12459 of this century is also predicted (Schw rer, Henne, & Tinner, 2014).

12460 Alpine, Scandinavian, and Icelandic glaciers are projected to retreat. The range of losses depends of
 12461 climate modelling scenario and varies from 20% to 90% from the 2006 ice volume (IPCC, 2014b).The

extent of tundra in the region is limited northward by the ocean and by a small area of Arctic desert. Shrinking of the tundra belt due to loss of permafrost, most active in Siberia and in the southern Arctic (IPCC, 2014), with subsequent replacement by coniferous forests is expected by the end of the 21st century (Lindner et al., 2010, Kharuk, Ranson, Im, & Naurzbaev, 2006).

It is likely that aridification will reduce the geographical ranges of broadleaved forests, and that Euro-Siberian conifers at medium and high elevations will be displaced by Mediterranean sclerophyll species. Mediterranean mountains might lose their key role as refugia for cold-adapted species and this may have a disproportionate impact on phylogenetic diversity (Barbet-Massin et al., 2012; Benito Garzon et al., 2008; Ruiz-Labourdette, Nogués-Bravo, Ollero, Schmitz, & Pineda, 2012; Wilfried Thuiller et al., 2011, 2014).

Mediterranean-type ecosystems will suffer from rising temperature, rainfall change (declining in most cases), increased drought, and increased fire frequency (IPCC, 2014b).

Increased seasonal thawing of permafrost due to climate warming may alter the hydrological and thermal regime of polygon and palsa peatlands, as well as their spatial structure (Minayeva & Sirin, 2009, 2010; Minayeva et al., 2017b). However, many forecasts of the effect of climate change are ambiguous. Climate change may lead to permafrost degradation in the southern parts of the Asian territory of Russia, whereas forest is likely to expand into the forest tundra. Fires on peatlands and other paludified habitats have already become more frequent from the tundra to the steppe (Minayeva, Sirin & Stracher, 2013).

The carbon stored in natural vegetation is likely to increase under business-as-usual scenarios of climate change (Friend et al., 2014). However, changes in plant respiration and release in soil carbon will be such that there will be a net release of soil carbon in forest and grassland ecosystems (Wolf, Lazzarotto, & Bugmann, 2012). The potential standing stock of plant biomass in Russia is predicted to increase in response to elevated precipitation (Shuman & Shugart, 2009).

Box 3.4: 21st century scenarios for mountain ecosystems

Trends in future climate, land use and invasion projections for mountain systems

Similar to other regions of the world, mountain systems in Europe and Central Asia are projected to warm at a higher rate than other areas (Rangwala, Sinsky, & Miller, 2013). Climate models predict an average temperature change for mountain ranges worldwide of 2-3°C by 2070 and 3-5°C by the end of the century (Nogués-Bravo, Araújo, Errea, & Martínez-Rica, 2007), with greater increases for mountains in northern latitudes than in temperate and Mediterranean climates, with severe impacts expected on biodiversity. Additional threats on biodiversity are represented by invasive species, predicted to increasingly invade mountains under climate change (e.g. Pauchard et al., 2009; Petitpierre et al., 2015) and by land-use change and pollution (Yoccoz, Delestrade, & Loison, 2010). Biological responses to ongoing global changes were already evidenced, and these trends are expected to intensify in the future (Pereira et al., 2010), with complex biophysical dynamics in mountain systems (Bugmann et al., 2007).

Vegetation

Both mechanistic and correlative modelling approaches predict an advance of the treeline, and a consequent reduction of the alpine and nival areas (Körner, 2012; Pellissier et al., 2013). Currently, however, the main driver of upward treeline shifts is land abandonment (Gehrig-Fasel, Guisan, & Zimmermann, 2007), which shows the importance of considering land-use changes in combination with climate change. Most models project strong changes in composition and structure of temperate and Mediterranean mountain forests, affecting biodiversity and ecosystem services, such as protection against rockfalls and avalanches (Elkin et al., 2013). 21st century climate change scenarios predict a massive reduction of high-elevation grassland plant diversity and high community turnover, possibly changing the structures of current natural ecosystems (Engler et al., 2011b), but first extinctions may only be observed in several decades (e.g. 40 years at high elevation in the Swiss Alps; Engler

et al. 2009). For the whole European Alps, Dullinger et al. (2012) predicted a range reduction around 44-50% for 150 high-mountain species, including several endemics, with possible delays in extinctions (extinction debt). Species that already occur near mountain tops with no possible escape upward have a greater risk of extinction, as predicted for Europe (e.g. Dirnböck, Essl, & Rabitsch, 2011; Dullinger et al., 2012; Engler et al., 2011; Randin et al., 2009; Thuiller, Lavorel, Araujo, Sykes, & Prentice, 2005), Spain (Felicísimo, Muñoz, Villalba, & Mateo, 2011), or Norway (Wehn, Lundemo, & Holten, 2014). On the other hand, mountain systems that have pronounced microclimatic variations may allow species to persist locally (Randin et al., 2009; Scherrer & Körner, 2011; Trivedi, Berry, Morecroft, & Dawson, 2008). The melting of permanent snow and ice may also provide new potential habitats at higher elevations than currently found, although the formation of soils may take several hundred years (Engler et al., 2011b; Guisan & Theurillat, 2001). In the lower alpine areas, losses of grasslands are to be expected by upward shift of treelines (Dirnböck, Dullinger, Grabherr, & Dirnb, 2003; Körner, 2012; Pellissier et al., 2013), with a 2.2 degree warming leading to an upward shift of the treeline of about 400m, to a reduction of the lower alpine zone of more than 20% and of the upper alpine and nival zones of more than 50% (Körner, 2012; see Theurillat & Guisan, 2001 for 3.3 degree warming). Counteracting these trends in alpine habitat losses would require the maintenance of large summer farms (Dirnböck et al., 2003). Model simulations show that pasture-woodland systems on lower elevation mountains (e.g. Jura mountain in Western Europe), in particular, may suffer from increased drought, resulting in progressive shifts from Norway spruce to beech under moderate warming, or to Scots pine under extreme warming. This may require changes in silvopastoral practices, such as intensifying pasturing and moving to mixed herds (e.g. cattle, horses, sheep, and goats) to prevent forest encroachment and the loss of species-rich open grasslands and forest-grassland ecotones (Peringer et al., 2013). Also using simulations combining land-use and climate change scenarios for the Larch in the French Alps, Albert et al. (2008) conclude that ongoing and future agri-environmental policies have to be quickly adapted to protect biodiversity and ecosystem services provided by subalpine grasslands.

Much fewer modelling studies exist that examine the effects of pollution on plant species and vegetation in mountains of Europe and Central Asi. In the Jizera Mts of Northern Bohemia, ongoing nitrogen deposition results in an unbalanced nutrition of Norway spruce, causing crown defoliation that may ultimately decrease the upper optimal limit for the young spruce stands (Lomský et al., 2012), but positive effects of nitrogen deposition combined with climate warming were also observed in other mountains (Hauck et al., 2012), making prediction of pollution effects on vegetation still uncertain.

More studies exist on invasions by exotic plants in mountain areas. Although mountains areas were long considered as more preserved than lowlands from biological invasions (Pauchard et al., 2009), recent modelling studies predict increasing threats by invasive alien species in mountains of the region under climate change, sometimes combined with land-use change (Cervenkova & Münzbergová, 2009; Hof, 2015; Kašák, Mazalová, Šipoš, & Kuras, 2015; Petitpierre et al., 2015; Simpson & Prots, 2013).

End of Box 3.4.

3.5.1.4 Emerging drivers of change

Russian tundra is expected to be further fragmented, polluted and degraded by projected transport systems, settlements and industrial sites (Russian Government, 2013). A warmer climate and longer period of open sea water will make territories of Polar Islands more available for tourism which can become a negative factor of disturbance for animals and birds (Bagin, Melnikov, & Tambiev, 2011)

3.5.2 Freshwater systems

3.5.2.1 Species distribution and conservation status

Freshwater molluscs, most aquatic insects, headwater fishes and crustaceans are expected to contract their ranges due to climate change with greater than 2° C warming by 2070 (IPCC Assessment Report 4, scenarios A1B and A2), while aquatic macrophytes, dragonflies and downstream fishes have the

potential to expand their range, assuming they are able to disperse and that no other threats will impede their expansion (Alahuhta, Heino, & Luoto, 2011; Capinha, Larson, Tricarico, Olden, & Gherardi, 2013; Cordellier, Pfenninger, Streit, & Pfenninger, 2012; Sami Domisch et al., 2013). Stenothermal species (with narrow thermal ranges, such as Arctic charr, *Salvelinus alpinus*) will probably shift range or become locally extinct, whereas eurythermal species (with a wide thermal tolerance, such as common carp, *Cyprinus carpio*) will likely be able to adapt to new thermal regimes. At high latitudes, cold-adapted species, such as salmonids, and amongst them notably the northernmost freshwater fish species, Arctic charr, will likely experience major population reductions, a continuation of current trends (Brucet et al., 2010; Moss, 2015).

In a large analysis of projected bioclimatic envelopes for 323 freshwater plants, 470 fishes, 659 molluscs, 133 odonates, 54 amphibians, five crayfish and four turtles across 18,783 European catchments Markovic et al. (2014) found that in Europe under the climate change scenario A1B for 2050, 6% of common and 77% of rare species are predicted to lose more than 90% of their current range and 59% of all freshwater species are predicted to lose habitat suitability across more than 50% of their current range. They forecasted that nine molluscs and eight fish species should experience 100% range loss. As the most species-rich group, molluscs are particularly vulnerable due to the high proportion of rare species and their relatively limited ability to disperse. Furthermore, around 50% of molluscs and fish species will have no protected area coverage given their projected distributions. Dragonflies might be able to shift or even expand their ranges, assuming they are able to disperse to track suitable climate.

Caddisflies (order Trichoptera) are among the most sensitive taxa to climate change. About 20% of the Trichoptera species in most southern European ecoregions and about 10% in high mountain range possess characteristics that make them vulnerable to climate change (Hering et al., 2009).

Macroinvertebrate communities are central to ecological assessments of river and stream ecological quality under the Water Framework Directive. Systems by which these assessments are made could be upset by effects of climate change (Hassall, Thompson, & Harvey, 2010). For example, range shifts in Odonata could change scores derived from the Biological Monitoring Working Party (BMWP) system that is used and have effects consequently on conservation monitoring and assessments (Moss, 2015) (Moss 2015). The Plecoptera are particularly crucial, since they have been allocated some of the highest BMWP scores and have been shown to be “cold-adapted” and to decline in species richness with increasing temperature (Jani Heino, Virkkala, & Toivonen, 2009).

Many southern countries in Europe, such as Portugal, Spain, Italy, Greece and Turkey are home to high numbers of endemic and threatened species. The consumption of freshwater is expected to increase in the coming years, both as a result of increasing demand and climate change, posing a threat to freshwater habitats and species (Jörg Freyhof & Brooks, 2011). This is also true for the Crimean Peninsula where a highly endemic fish fauna is restricted to a few small streams, from which water is already extracted in large and unsustainable amounts.

3.5.2.2 Community composition

Under scenarios of strong climatic impacts (e.g. SRES A1B and A2), freshwater ecosystems are projected to undergo large changes in community structures and therefore loss of ecological integrity. Local species richness in freshwater systems is projected to decline for most taxa due to climate change, but this is expected to be partially compensated by colonisation of new species; species turnover for instance is projected to increase for freshwater stream fishes in France by about 60% by 2080 (Buisson, Thuiller, Lek, Lim, & Grenouillet, 2008), and aquatic plants and dragonflies local richness

12600 is expected to increase in Western Europe assuming unlimited dispersal (Markovic et al. 2014). Floating
 12601 invasive alien plant species are projected to become more prevalent in the region (Meerhoff et al.,
 12602 2012; Moss, 2015).

12603 Global warming and associated changes in water level and salinity will likely seriously affect community
 12604 composition in lakes and ponds (Brucet et al., 2012; Brucet et al., 2009; Jeppesen et al., 2012, 2015)
 12605 with some effects already being observed. For example, complex changes in fish community structure
 12606 may be expected owing to the direct and indirect effects of temperature, and indirect effects of
 12607 eutrophication, water-level changes and salinisation on fish metabolism, biotic interaction and
 12608 geographical distribution (Jeppesen et al., 2010). Local extinctions and changes in community
 12609 composition are likely in the coldest and the most arid regions, after the expansion of the warm
 12610 adapted species. Fish species richness will likely increase in many continental lakes owing to a
 12611 poleward expansion of warm-tolerant species.

12612 Enhanced salinization may also promote changes in fish assemblages leading to a greater importance
 12613 of small-bodied or planktivorous species, and therefore, a strengthening of eutrophication effects
 12614 (Brucet et al., 2010; Jeppesen et al., 2010).

12615 Several studies have reported projected impacts on community composition of invasive alien species,
 12616 in isolation or in combination with climate change. For example the Louisiana red swamp crayfish
 12617 *Procambarus clarkia*, a highly invasive species, is projected to expand its range throughout Europe in
 12618 the coming decades (Ellis, Jackson, Jennings, England, & Phillips, 2012), the African clawed frog
 12619 *Xenopus laevis* is expected to become invasive in Europe (Ihlow et al. 2016), as is the Asian gudgeon
 12620 *Pseudorasbora parva*, which has been predicted to expand its invasive range throughout Europe and
 12621 Central Asia with significant ecological implications for its fish diversity (Fletcher et al., 2016). In some
 12622 instances, the extent of overlap between native species and their invasive alien competitors is
 12623 projected to increase, this is the case of the native depressed river mussel (*Pseudanodonta*
 12624 *complanata*) and its invasive competitor *Dreissenia polymorpha*. In other cases, climate change can
 12625 partially reduce the overlaps between invasive and native species. This is the case for the invasive
 12626 *Pacifastacus leniusculus*, which is projected to lose suitable habitat due to climate more than the native
 12627 white-clawed crayfish *Austropotamobius pallipes* (Gallardo & Aldridge, 2013). Most of these patterns
 12628 also emerge with lower emission scenarios (e.g. SRES B1 and B2 climate scenarios) but with less
 12629 dramatic change (Capinha et al., 2013; Cordellier et al., 2012; Sauer et al., 2011) (Buisson et al. 2012).

12630 An increase in species richness at warmer temperature is predicted for phytoplankton and periphyton
 12631 in shallow lakes, while the opposite is true for macroinvertebrates and zooplankton (Brucet et al.,
 12632 2012; Jeppesen et al., 2012; Meerhoff et al., 2012). Another study (Shurin et al., 2010) suggested that
 12633 potential impacts of global change on lake zooplankton biodiversity will depend on the relative
 12634 magnitudes and interactions between shifts in chemistry and temperature. The study shows that
 12635 temporal fluctuations in the chemical environment tend to exclude zooplankton species whereas
 12636 temperature variability tends to promote greater richness. Thus, increasing frequency of extreme
 12637 events and greater ranges of variability may be as or more important than changes in average
 12638 conditions as drivers of zooplankton community diversity.

12639

12640 3.5.2.3 Ecosystem functioning

12641 In inland waters, total biomass stock of planktonic autotrophs has been projected to either remain
 12642 stable or increase under business-as-usual climate projections for the 21st century (Elliot et al., 2005;
 12643 Markensten et al. 2010, Arheimer et al., 2005). Mooij et al. (2007) predict that cyanobacteria blooms
 12644 will increase productivity despite related declines in diatoms and green algae. Cyanobacteria being a

poor food source for zooplankton, these and higher trophic levels are likely to decline as a result of climate change. Moreover, due to reduced critical nutrient loading and eutrophication, temperate lakes (with temperature varying between 2 and 22 degrees) are likely to switch from the clear to the turbid state in a 3 degree-warming scenario.

Changes in important functional traits are expected in the future due to global warming. For example, the body size of fish and zooplankton is expected to decrease under higher temperature with negative consequences for the functioning of the food web and the biodiversity of aquatic ecosystems (Daufresne et al., 2009; Emmrich et al., 2014; Meerhoff et al., 2012). Global warming is also expected to affect other fish life-history traits (e.g. shorter life span, earlier and less synchronized reproduction), as well as the feeding mode (i.e. increased omnivory and herbivory); behaviour (i.e. stronger association with littoral areas and a greater proportion of benthivores); and winter survival (Jeppesen et al., 2010). The increased dominance of smaller fish and omnivory will lead to stronger predation by fish on zooplankton and weaker grazing pressure of zooplankton on phytoplankton in warmer lakes (Jeppesen et al., 2014). This will have negative consequences for the ecological status of shallow lakes. Importantly, changes in fish communities that occur with global warming partly resemble those triggered by eutrophication. This implies a need for lower nutrient thresholds to obtain clear-water conditions and good ecological status in the future (Jeppesen et al., 2010; Meerhoff et al., 2012).

Increased salinity due to global warming, water abstraction and pollution may also have negative consequences for the ecosystem structure, function, biodiversity and ecological state of lakes, temporary and permanent ponds, wetlands and reservoirs (Brucet et al., 2009; Cañedo-Argüelles et al., 2016; Jeppesen et al., 2015).

3.5.2.4 Emerging drivers of change

Aquaculture is growing worldwide, already providing more than 50% of the fish and other aquatic organisms on the market. Development of aquaculture, which is now mainly focused on intensive technologies, including integrated agriculture-aquaculture multi-trophic farming, pond culture, cage-culture, recirculating aquaculture systems (RAS) technologies (Karimov, 2011; Thorpe et al., 2011b) might have contrasting effects on biodiversity. On one hand aquaculture might substitute the demand for natural fish and other aquatic species and will promote the conservation of biodiversity. On the other hand, aquaculture has historically been the source of invasions in some parts of the region, specifically in Eastern Europe and Central Asia. Lack of adequate management, development of aquaculture and use of genetically modified organisms can further increase invasions of alien species and threaten biodiversity and/or endemic species.

The Brönmark & Hansson (2002) review on environmental threats to lakes and ponds predicted that biodiversity in fresh waters will, in most parts of the world, have decreased considerably by the year 2025. Changes in biodiversity may in turn affect freshwater ecosystem processes such as primary productivity, detritus processing and nutrient transport at the water-sediment interface. In addition, loss of species at higher trophic levels may have strong repercussions down the food chain (Brönmark & Hansson, 2002). Furthermore, these authors suggested that “old” problems such as eutrophication, acidification and contamination, may become less of a problem in the future, whereas “new” threats such as global warming, UV radiation, invasive alien species and endocrine disruptors most likely will increase in importance.

12688 3.5.3 Marine systems

12689 3.5.3.1 *Species distribution and conservation status*

12690 Direct and indirect impacts of climate change on species distribution and abundance have been
12691 predicted for all marine systems and virtually all taxonomic groups investigated.

12692 Climate change effects on Arctic and sub-Arctic marine mammal and bird species will vary by life
12693 history, distribution, and habitat specificity with some major negative effects on ice-obligate species
12694 (such as hooded seal, narwhal and ivory gull (Moore & Huntington, 2008)); some species coming to
12695 the region seasonally may benefit from ice loss (killer whale, grey whale) (Larsen et al., 2014). It is
12696 projected that polar bear number will decrease dramatically with approximately two-thirds of the
12697 world's polar bears extirpated by the middle of the 21st century under A1B scenario (Amstrup, Marcot,
12698 & Douglas, 2013; Larsen et al., 2014). There is a risk that Arctic shelf species might become locally
12699 extinct due to shortage of climatically suitable shelf habitat (Fossheim et al., 2015a).

12700 In the North East Atlantic, pelagic ecosystems and taxa are projected to display higher modifications
12701 than demersal communities, a pattern explained in some regions by the influence of regional
12702 topography (e.g. North Sea (Weinert et al. 2016)). This does not mean that demersal species are not
12703 affected by the projected changes, only that rates are variable. For instance, marine fish in the North
12704 Sea have projected poleward shifts which can be up to two times higher than the observed current
12705 rate of shift (Cheung et al., 2016). Benthic communities of the North Sea were also shown to be
12706 strongly impacted under the IPCC AR4 scenario A1B, with latitudinal northward shift projected in 2099
12707 for 64% of the 75 species examined by Weinert et al. (2016). Seabirds, which are often faithful to
12708 breeding colonies, are also expected to show important changes in their distribution in the North East
12709 Atlantic. For example, the ranges of 65% or 70% of 23 seabirds from the British Isles are expected to
12710 shrink by 2100 under two emission scenarios (IPCC AR4 climate change scenario A1B and A2
12711 respectively) and under the hypothesis of unlimited dispersal; this value increases to 100% (and all of
12712 them lose at least 25% of their range) with no dispersal (Russell, Wanless, Collingham, Huntley, &
12713 Hamer, 2015).

12714 Less information is available on projected impacts of fisheries in the region. For the Atlantic cod and
12715 the European seabass, under a scenario of an increase in demand of 5.6% per year, a decline of the
12716 spawning stock sizes of the North Sea cod by 97% is predicted toward by 2050, compared with a
12717 scenario with a stable demand (Quaas, Reusch, Schmidt, Tahvonen, & Voss, 2016). Cascading effects
12718 are also projected along the trophic network: by 2040, climate change, in particular summer warming,
12719 is projected to lower the abundance of the copepod *Calanus finmarchicus* which is used as a prey by
12720 cod in the North East Atlantic (Kamenos, 2010).

12721 Some catch species will also have reduced survival and fertility due to direct and indirect impact of
12722 climate change. For instance, Baltic Sea cod eggs require certain environmental conditions regarding
12723 oxygen (>2 ml/l oxygen) and salinity (> than 11 g/kg). Physical and chemical changes in the Baltic will
12724 reduce cod reproductive potential by 75% by 2100 (Neumann, 2010).

12725

12726 3.5.3.2 *Community composition*

12727 Species turnover is projected across all marine systems in the region and across a large range of marine
12728 habitats and taxa. Reductions in sea ice in the central Arctic are likely to enhance invasion of benthic
12729 taxa from the Pacific to the Atlantic due to more freely flowing currents (Hunt et al., 2016, Renaud et
12730 al., 2015). The Chukchi and the Barents Seas along with the western part of the Kara Sea are the most

12731 likely locations for the expansion of some boreal benthic species and communities (Renaud et al.,
12732 2015).

12733 The advection of zooplankton to the Arctic Basin along the Eurasian shelf is projected to cease during
12734 the 21st century, as revealed by models based on climate scenario A1B, with increased participation of
12735 the species of temperate origin in the communities of the Eurasian Arctic Seas (Wassmann et al., 2015).
12736 In particular, for the Barents Sea by 2059, zooplankton of Atlantic origin will increase and zooplankton
12737 of Arctic origin will decrease under moderate climate change (SRES B2 scenario, Ellingsen, Dalpadado,
12738 Slagstad, & Loeng, 2008).

12739 Boreal fish species replacing Arctic species are known to be opportunistic generalists, and their
12740 expansion is known to alter the structure of Arctic food webs and is predicted to increase the
12741 connectivity between benthic and pelagic habitats. As a result, more densely connected and less
12742 modular Arctic marine food-webs are expected to emerge (Kortsch, Primicerio, Fossheim, Dolgov, &
12743 Aschan, 2015).

12744 Models of fish invasions have shown that the rate of spread of non-native species in the Barents Sea
12745 are five times higher than the global average, with the central Barents Sea fish community spreading
12746 northwards and Arctic community retreating. This shift appears to be taking place at a speed at >159
12747 km per decade.

12748 For some marine alien species already introduced in the North East Atlantic, like the American clam,
12749 *Ensis directus* (Raybaud, Beaugrand, Dewarumez, & Luczak, 2014), and the Pacific oyster, *Crassostrea*
12750 *gigas* (Jones, Dye, Pinnegar, Warren, & Cheung, 2013), expansion of their current range is projected
12751 with high level of confidence by the end of the 21st century, under medium to severe climate change
12752 scenarios.

12753 In the North East Atlantic, 21st century scenarios of moderate (e.g. IPCC RCP 4.5, 550ppm B1) to severe
12754 climatic change (e.g. IPCC RCP 6.0 or RCP 8.5, 720ppm A1B), are projected to generate important
12755 changes in marine community structure, population abundance, and species range and richness
12756 (Beaugrand, Edwards, Raybaud, Goberville, & Kirby, 2015; Blois, Zarnetske, Fitzpatrick, & Finnegan,
12757 2013; Cheung et al., 2009; Garcíá Molinos et al., 2016; Jones & Cheung, 2015). These scenarios
12758 establish with high confidence that communities are modified because of the joint effect of loss of
12759 species and colonization by new species (i.e. species turnover). In addition, the projections highlight
12760 that expansion of species ranges are prevailing over species loss or range contraction, thus leading to
12761 a transient net local increase in richness, particularly around the 40-30°N line of latitude (**Figure 3.57**).

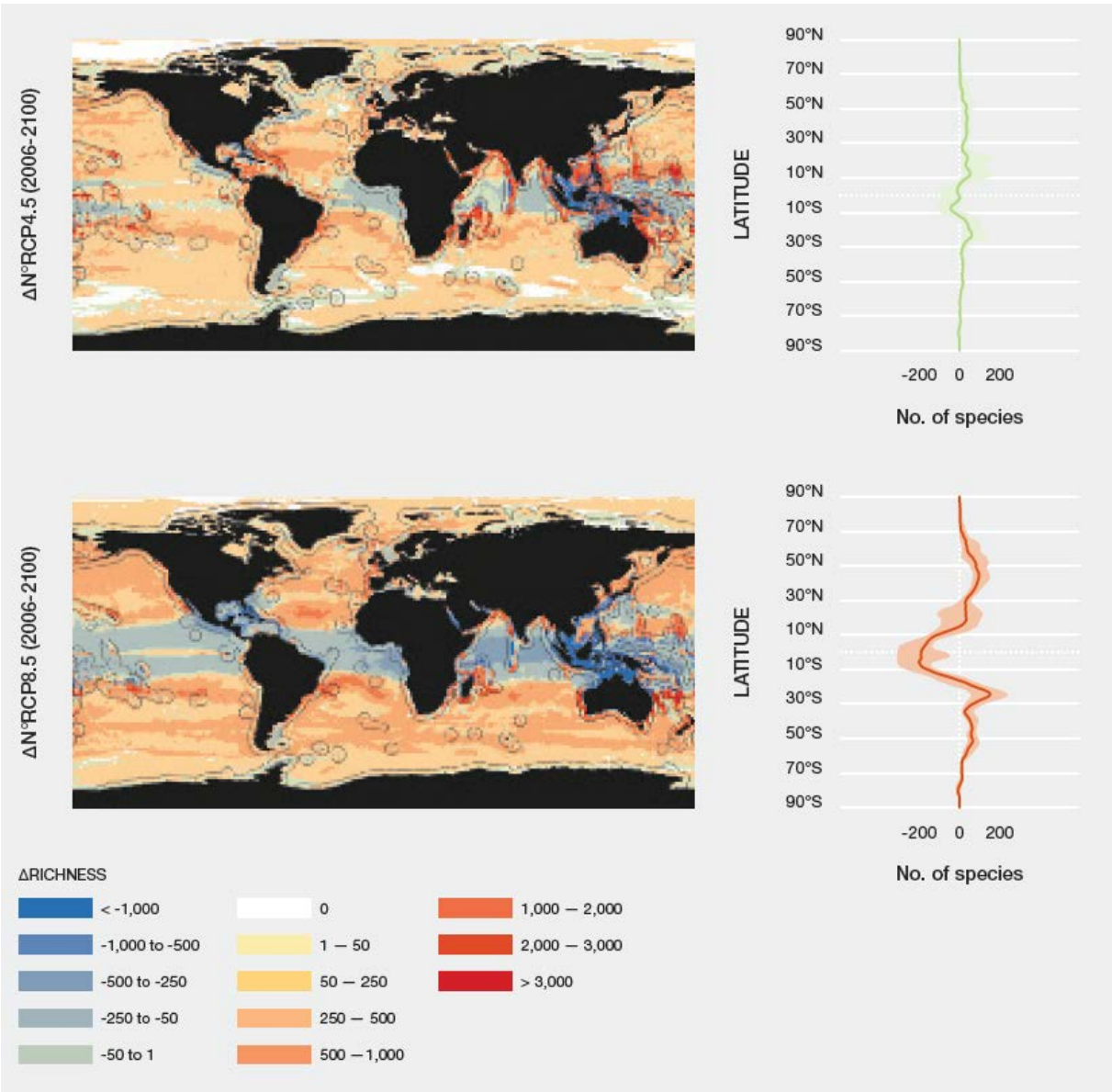


Figure 3.57: Differences between current (2006) and projected (2100) species richness (ΔRichness) based on models of 12,796 marine species from 23 phyla for IPCC RCP 4.5 (top) and RCP 8.5 (bottom) climate change scenarios. Source: Reprinted by permission from Macmillan Publishers Ltd: Nature Climate Change (García Molinos et al., 2016), copyright (2016).

3.5.3.3 Ecosystem extent and function

Across all marine systems and habitats, 21st century climate change and ocean acidification are projected to induce changes in extent and functioning of ecosystems. Most of the Eurasian Arctic Seas lie within today’s seasonal ice zone. The general trend of “borealization” of the region is expected to continue (Fossheim et al., 2015), inducing habitat gains and losses and a large species turnover; changes in phenology and production; substantial food web reorganizations; and changes in ecosystem functioning (Kortsch et al., 2015; Larsen et al., 2014).

In the Baltic Seas, maximum sea-ice cover is expected to decline by 75% under high climate change (SRES A1B) and by half under the most optimistic scenarios of climate change (B1) by the end of the 21st century. Melting sea ice will decrease water salinity and the resulting warming and changes in

12778 water density are projected to promote instability in water stratification thereby reducing the areas of
 12779 suboxic water (with < 2 ml/L of oxygen) (Neumann, 2010)

12780 Kelp forest ecosystems (*Laminaria hyperborea*) are expected to expand to northern territories under
 12781 all plausible climate change scenarios. This, coupled with significant loss of suitable habitats, is
 12782 projected at low latitude range margins, including in areas where long-term persistence was inferred
 12783 (e.g. north-western Iberia) (Assis, Lucas, Bárbara, & Serrão, 2015), might have important consequences
 12784 on the genetic diversity, and adaptive potential, of these habitat-structuring species (Assis, Araújo, &
 12785 Serrão, 2017). A significant loss of maerl beds, dominated by coralline algae, is also predicted to occur
 12786 by 2100 in the North East Atlantic, due to elevated pCO₂ (Brodie et al., 2014).

12787 Species range changes, phenological reactions, and variations in production, is expected to cause the
 12788 Eurasian Arctic Seas ecosystem structure and functions to change (Larsen et al., 2014).

12789 Though primary production on ocean shelves is expected to increase (Hunt et al., 2016), so far no
 12790 unidirectional changes in the primary production in the individual Eurasian Arctic Seas have been
 12791 observed. Reliable trends in its variation (increasing) were ascertained for the Barents, and Kara seas
 12792 (Vetrov & Romankevich, 2011). There are two peaks in primary production in the Arctic Seas: spring
 12793 ice algal peak and consecutive phytoplankton bloom. The role of the first one is expected to diminish;
 12794 the timing of maximum phytoplankton production is expected to change and to influence the
 12795 variability in time-lags between ice algal and phytoplankton peak production (from 45 to 90 days; Ji et
 12796 al., 2013, Kędra et al., 2015). The frequency of mismatch between peak in demand from marine grazers
 12797 and supply of their food, will increase. This will alter trophic flows throughout the food chain (Ji et al.,
 12798 2013). The spatio-temporal mismatch between the breeding season and the peak in food availability
 12799 will potentially have a negative impact on seabird populations (Grémillet & Boulinier, 2009).

12800 Phenological changes due to climate change and chemical changes have been already observed and
 12801 further projected in the future. For instance, the decrease of anadromy prevalence of Arctic char (over
 12802 50% to the end of 21st century with high-levels of global warming, under the IPCC AR4, A2 emission
 12803 scenario) because of the increase of lake and terrestrial catchments productivity (Finstad & Hein,
 12804 2012). Seasonal Cyanobacteria blooms in the Baltic are projected to start earlier and last a month
 12805 longer by the end of the 21st century (Neumann, 2010). Invasive species like the Pacific oyster,
 12806 *Crassostrea gigas*, have also shown phenological changes. Specifically, reproductive effort and
 12807 spawning periods are changing as a response to increased seawater and phytoplankton concentration
 12808 (Thomas et al., 2016).

12809 In the North East Atlantic and the North Sea, the projected general trends point to accelerating changes
 12810 in ecosystem functioning, notably due to the effect of climate change on nutrient availability, and
 12811 changes in timing of phytoplankton production, phytoplankton and zooplankton biomass, with
 12812 cascading effects on the trophic network (Friocourt, Skogen, Stolte, & Albretsen (2012) and examples
 12813 in Soto (2001)). For instance, larval cod survival probability is declining by 22-44% in the North Atlantic,
 12814 notably because of starvation effect due to food limitations (Kristiansen, Stock, Drinkwater, &
 12815 Curchitser, 2014). And the growth and weight of adult cod is also projected to be declining under IPCC
 12816 Assessment Report scenario RCP 8.5 (highest green-house emission scenario for this assessment),
 12817 because of physiological constraints (Butzin & Pörtner, 2016). Physiological processes as well as
 12818 metabolic pathways will thus be modified as a response to climate change and ocean acidification.
 12819 Responses may, however, be very different across taxa: for instance, autotrophs like seagrasses and
 12820 many macroalgae are expected to display higher growth and photosynthetic rates under elevated pCO₂
 12821 (Koch, Bowes, Ross, & Zhang, 2013), whereas calcareous algae like maerl are likely to suffer from ocean
 12822 acidification (Brodie et al., 2014). Particularly well documented are changes in breeding phenology and
 12823 success and the timing of migration of seabirds of the North East Atlantic (e.g. effect on breeding

phenology, (Morten Frederiksen, Harris, Daunt, Rothery, & Wanless, 2004). Among other documented changes are migration patterns. For instance, migration patterns of the North East Atlantic mackerel are projected to change under moderate and high climate change scenarios (RCP 4.5 and 8.5, respectively). The outcome of these scenarios is that this living natural resource could expand in the near future.

3.5.3.4 Emerging drivers of change

Discovery of gas and oil fields across Europe and Central Asia, especially in the Arctic circle and the far north-east of the region (Sakhalin shelf and Kamchatka) pose a threat to terrestrial and marine biodiversity (Kontorovich, Eder, Filimonova, Nemov, & Provornaya, 2013).

Enormous amounts of manganese, copper, nickel and cobalt are found on or beneath the seafloor (World Ocean Review, 2014). Demand for these resources are set to increase since they are needed for developing clean technologies, such as making wind turbines or hybrid cars. Deep-sea mining has not yet begun, mostly for technical reasons, but there has been an increase in the number of applications for mining contracts and it is estimated that by the end of 2017 there will be about 27 projects worldwide (Wedding et al., 2015). Research to determine the impacts of deep sea mining has shown that deep-sea mining cannot be done without directly destroying habitats and species, resulting in biodiversity loss (Vanreusel, Hilario, Ribeiro, Menot, & Arbizu, 2016) and indirectly degrading large volumes of the water and seabed area with the polluted sediment plume it generates (Van Dover et al., 2017). This mining requires enormous areas: a single 30-year operation license to mine metal-rich nodules will involve an area about the size of Austria. Most mining-induced loss of biodiversity in the deep sea will not recover for decades or centuries, given the very slow rates of recovery of many deep-sea species and ecosystems (Vanreusel, et al. 2016).

Shipping is expected to double by 2050, emphasizing the need for alternative shipping routes. Alternative routes are essential to minimize impacts caused by the increased threats from shipping accidents and oil spills (Kotta et al., 2016).

With projected sea-ice declines, large swaths of Arctic Ocean will be opened up to shipping and fisheries (Jørgensen et al., 2016; Mullon et al., 2016). This will cause additional pressure on the biodiversity of the region, speeding introductions of boreal fauna (Renaud, Sejr, Bluhm, Sirenko, & Ellingsen, 2015), and possibly reducing bottom complexity. Changes in advection are projected to accelerate the transboundary pollution effects increasing the number of contaminants in the food web (Jørgensen et al., 2016).

The continuing enlargement of the Suez Canal will allow greater cohorts of deeper living biota to enter the Mediterranean Sea, enhancing the risk of establishment and spread (Galil et al., 2017). Increase in commercial shipping and recreational boating will enhance the introduction and secondary spread of non-native biota.

3.6 Knowledge gaps

Knowledge gaps concern a) the full geographic (and temporal) coverage of past, current, and future trends of some ecosystem types and some taxa across Europe and Central Asia, b) patterns and underlying mechanisms of the biodiversity – ecosystem service relationship, and c) consideration of indigenous and local knowledge for all ecosystem types and taxa.

12866 **Geographic gaps**

12867 Overall, we found large gaps in knowledge on habitat extent and intactness, and species conservation
 12868 status and trends for Eastern Europe and Central Asia. For instance, there is no systematic monitoring
 12869 of plant and animal species across the range of these subregions. This is of particular concern given
 12870 the size of these subregions and the diversity of habitat and species there. Outside the European Union
 12871 long-term monitoring data is available almost exclusively for protected areas, which poses the risk of
 12872 underestimating overall biodiversity trends in these regions.

12873 **Role of drivers**

12874 Information on future trends in biodiversity was predominantly focused on the impact of climate
 12875 change, especially on plants and vertebrate species. There were very few studies investigating the
 12876 impact of land-use change and even fewer investigating future projected impacts of pollution, invasive
 12877 species, fishing and other drivers of change.

12878 It was often impossible to quantify the relative role of drivers of change in determining trends in
 12879 species and ecosystems. This was due to lack of synthetic studies on this subject and the limited ability
 12880 to meta-analyze the literature to provide this evidence. Therefore, the attribution of drivers to trends
 12881 was based on the qualitative expert assessment of the authors rather than on quantitative empirical
 12882 evidence from experimental or quasi-experimental studies.

12883 **Marine systems**

12884 Most marine systems are hidden to human eye and therefore lack of visibility, knowledge gaps, and
 12885 lack of concerted actions are regularly pointed out for marine systems (e.g. Allison & Bassett, 2015;
 12886 Mccauley et al., 2016).

12887 Nevertheless, the rate of description of new marine species has been increasing, since 1955, at a higher
 12888 rate than for terrestrial species (Appeltans et al., 2012). Still, it is estimated that between one-third
 12889 and two-thirds of marine species are still to be described, with estimates of the total number falling in
 12890 the range of 0.7 to 1 million (as compared to the 226,000 species currently described). Under-
 12891 estimation of marine diversity is not restricted to remote and under-studied locations. It also holds in
 12892 Europe and Central Asia, with the increasing discovery of cryptic species (i.e. species that are not, or
 12893 are hardly, distinguished according to morphological criteria). This underestimation of marine diversity
 12894 implies that the trends are incomplete for most marine taxa.

12895 An important gap in knowledge regarding current as well as future changes is genetic responses to
 12896 environmental changes. Only few taxa, among them fishes and algae, have been studied so far (e.g.
 12897 Araújo et al. (2016); Assis et al., (2016); Hutchinson et al. (2003); Nicastro et al. (2013)), but these
 12898 studies indicate changes in genetic diversity and genetic structure of marine species. Integration of a
 12899 genetic component is of paramount importance for conservation of genetic resources as well as for
 12900 modelling of future trends in marine biodiversity (Arrieta, Arnaud-Haond, & Duarte, 2010; Gotelli &
 12901 Stanton-Geddes, 2015).

12902 Until recently, scant attention was paid to marine ecosystems and most marine taxa in conservation
 12903 policies (e.g. see Habitat directive and species lists in the European Union). Only a small number of
 12904 species and few habitat types are included in Annex I of the Habitats Directive (EEA, 2015a). The gap
 12905 in knowledge is exemplified by the large percentage of species in the “unknown” category in the first
 12906 assessment of “good environmental status” in light of the newer Marine Strategy Framework Directive
 12907 (2008) in the European Union (**Figure 3.58**).

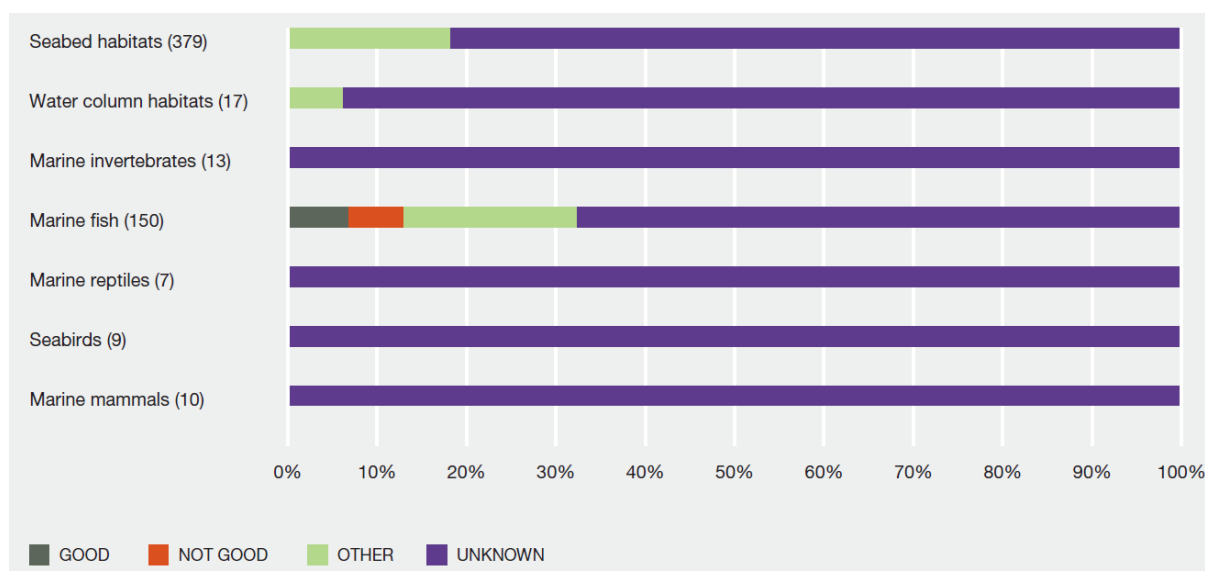


Figure 3.58: Knowledge and categorization of “good environmental status” in marine ecosystems of the European Union. Source: EEA (2015) - <http://cdr.eionet.europa.eu/>

Most long-term marine datasets (since the 1950s) concern pelagic ecosystems (e.g. Beaugrand et al. 2002), intertidal rocky shores (e.g. Mieszkowska, Kendall, Hawkins, Leaper, & Williamson, 2006), or specific taxa or taxonomic groups (in particular fishes, marine mammals or seabirds). Almost no data are available to document changes in subtidal rocky areas although they are rich in biodiversity and support key engineer species, for instance in subtidal kelp forests (Smale et al., 2013).

Open ocean plankton communities are also poorly known. It is estimated that, in each litre of seawater, there are on average 10 billion organisms, including viruses, prokaryotes, unicellular eukaryotes, and metazoans.

The most notable knowledge gap in marine biodiversity for Europe and Central Asia is the lack of data on status and trends of biodiversity in deep-sea areas (>200 m) despite canyons, seamounts and other important deep-sea habitats and ecosystems being present in Europe and Central Asia Seas and Oceans. Less than 1% of the deep-sea floor (UNEP, 2007; Rogers et al., 2015) and 0.4-4% of known seamounts (Kvile et al., 2014) have been sampled. Those that are known are mainly areas with sandy bottoms that can be trawled. This highlights significant gaps in basic knowledge, including lack of baseline data on biodiversity, abundance and biomass and its spatial and temporal variations. New habitat types and species are still being discovered on almost every deep-sea scientific cruise.

Some progress in addressing these knowledge gaps is signified by recent marine assessments. For instance, an assessment of data available and surveys needed was recently reviewed for kelp in the North East Atlantic (Araújo et al., 2016). The results from Tara Oceans and Malespina cruises and Ocean Sampling Day program, which collected genetic, morphological, and physico-chemical samples from stations around the world (about 35,000 biological samples and about 13,000 contextual measure taken at three different depths just for Tara Oceans) is now being analysed by a large international team of scientists. Metagenomes and meta-barcodes from stations are being built as well as quantitative and high-resolution image databases, and the first global studies are being published. (e.g. TARA Ocean (<https://www.embl.de/tara-oceans/start/>). IUCN recently coordinated an assessment dedicated to the Anthozoans of the Mediterranean Sea, which include, for instance, iconic species like the red coral (Otero et al., 2017).

Freshwater systems

12939 The chemical status of 40% of Europe's surface waters remains unknown (EEA, 2015f), considering that
 12940 good chemical status was only achieved for all surface bodies in five of the 27 European Union member
 12941 States, it is likely that the environmental conditions of some of these water bodies are poor.

12942 **Agricultural areas**

12943 Overall information on biodiversity trends in agricultural areas decreases from west to east. In
 12944 particular, studies on biodiversity and agriculture for Eastern Europe and Central Asia often focus on
 12945 drivers of biodiversity in agricultural areas rather than biodiversity trends (Smelansky, 2003), while
 12946 biodiversity is surveyed for semi-natural ecosystems rather than more productive agroecosystems in
 12947 these countries. Capacity building for monitoring biodiversity in agricultural areas in the eastern part
 12948 of the region is thus needed.

12949 The level of knowledge on biodiversity trends in agricultural areas and main direct drivers has
 12950 increased substantially during the last decade. However, most studies have used species richness or
 12951 abundance (and genetic diversity for animal breeds and plant varieties) as indicators of biodiversity.
 12952 Promoting a stronger focus on functional diversity in future studies and monitoring schemes may be
 12953 the best way to complement previous approaches. To better understand and predict biodiversity
 12954 trends in agricultural areas in Europe and Central Asia, it will be necessary: (i) to reinforce the
 12955 knowledge basis on the demography and population dynamics of species (including the role of
 12956 behaviour, density-dependent effects, and extinction debt); (ii) to account for small-scale spatio-
 12957 temporal effects and scale up biodiversity changes and trends from local to national and regional
 12958 levels; and (iii) to detail the effects of changes in agricultural practices (characteristics of the varieties
 12959 grown, harvesting techniques, types of pesticides used, etc.) to a greater extent (Kleijn, Rundlöf,
 12960 Scheper, Smith, & Tschamntke, 2011).

12961 **Urban areas**

12962 The data available for urban areas are mostly for the larger and more easily observed taxa, such as
 12963 vascular plants, birds and mammals. There is good data for bats, and reasonably good data on
 12964 amphibians, reptiles and some insect taxa, including butterflies. The small amount of data available on
 12965 taxa more difficult to observe and distinguish, such as Syrphids and other Diptera, suggest high levels
 12966 of diversity and numerous rare and threatened species (Kelcey, 2015). Thus, more surveying of such
 12967 taxa would generate valuable new knowledge on urban biodiversity.

12968 **Taxonomic gaps**

12969 While birds are arguably the most studied and best known group in Europe and Central Asia, there is
 12970 still one species, the large-billed reed-warbler, *Acrocephalus orinus* listed as being Data Deficient by
 12971 the IUCN and therefore having unknown extinction risk, and there are also 79 species with unknown
 12972 population trends in the European Union (EEA, 2015b). Long-term trends are rarely available. Low
 12973 capacity or difficult access means that regions such as Caucasus, the Arctic part of Europe, Romania,
 12974 Croatia, the Faroe Islands and the Azores are underrepresented in bird conservation status
 12975 assessments (BirdLife International, 2015).

12976 More substantial knowledge gaps exist for other terrestrial vertebrate groups. There are, respectively,
 12977 55 mammals, 11 reptiles and three amphibians that are classified as Data Deficient by the IUCN. In
 12978 addition, population trends are unknown for 100 of 1,026 bird species extant in the region and
 12979 assessed by IUCN as well as 263 of 537 mammals, 7 of 129 amphibians and 56 of the 268 species of
 12980 reptiles (IUCN, 2017c).

12981 There are at least 100,000 species of insects known in Europe, and an unknown number of
 12982 earthworms, arachnids, snails and other invertebrate species. However, it is plausible that several

12983 hundreds of thousands of species of invertebrates occur in Europe and Central Asia. Despite this
 12984 extremely high diversity, and importance for ecosystem services, only a very small proportion is listed
 12985 in the IUCN Red List. More specifically, there are only 2,132 species of terrestrial invertebrates in the
 12986 IUCN Red List that are extant in the Europe and Central Asia region. The majority of these are European
 12987 bees, which include 1,965 species (Nieto et al., 2014). Moreover, almost nothing is known about
 12988 species, trends and threats for this taxonomic group from Central Asia.

12989 There are no meaningful trends in geographic extent or population size of freshwater species available
 12990 for Europe and Central Asia. Therefore, a table of trends and importance of drivers was impossible to
 12991 produce. Of particular concern is the lack of data for freshwater invertebrates, for which even current
 12992 status is available only for a minority of species (EEA, 2010). For example, several freshwater crab
 12993 species have Data Deficient status according to the IUCN Red List, which highlights the need to increase
 12994 monitoring efforts globally but also in Europe and Central Asia.

12995 Similarly, almost a quarter of all European freshwater molluscs are Data Deficient and many might
 12996 prove to be threatened once enough data become available to evaluate their extinction risk. However,
 12997 the number of data-deficient species may well increase, since 76% of freshwater fishes and 83% of
 12998 freshwater molluscs have unknown population trends (Cuttelod et al., 2011b). Data are also deficient
 12999 for many other freshwater invertebrate groups (Balian, Segers, Lévêque, & Martens, 2008). This is
 13000 owing to several reasons such as lack of taxonomic information, knowledge gaps in geographical
 13001 coverage of data and lack of long-term data. These gaps need to be assessed urgently, by fostering
 13002 taxonomic research and monitoring and by making proprietary databases and databases under pay-
 13003 wall freely and openly available.

13004 Biases across taxonomic groups in marine systems are also largely documented (McCauley et al., 2015;
 13005 Poloczanska et al., 2013)(**Figure 3.59**). For instance, no extinction of marine animal species has been
 13006 documented in the past five decades (IUCN, 2017b), but only a small fraction of described marine
 13007 mammals has been evaluated and 17 that were assessed were determined to be Data Deficient (IUCN,
 13008 2017c; McCauley et al., 2015). This is exemplified by the extensive work carried out by Brooks et al.
 13009 (2016) in which marine taxa are not included, except for decapods. This is not surprising, since trend
 13010 data are not available even for 69% of the best-known group of marine organisms, the European
 13011 marine fish species.

13012 Availability of regional information on marine plankton and invertebrates is varied across Europe and
 13013 Central Asia, with certain systems having more information on biodiversity status available (e.g. the
 13014 North East Atlantic (OSPAR, 2017); the Mediterranean (Coll et al., 2010); and the Baltic (Ojavaer et al.,
 13015 2010). Most often, information remains descriptive: existence, abundance, geographical distributions
 13016 of species for instance, but little meta-information is available yet to discern conservation status.
 13017 OSPAR (OSPAR, 2008) lists five marine invertebrate species as threatened or declining in the North
 13018 Atlantic and North Sea since 2003, as well as a series of habitats formed by marine invertebrates (e.g.
 13019 mussel beds, deep sea sponge aggregations). In the Mediterranean, while much information is
 13020 available, marine invertebrate knowledge is often considered to be limited, with new species still being
 13021 described. There is also a high proportion of endemic species in the Mediterranean, especially sponges
 13022 and mysids (Coll et al., 2010). Mediterranean anthozoans have been reviewed in detail by IUCN,
 13023 showing that 13% of them are threatened while almost half lack sufficient data for assessing risk of
 13024 extinction (Otero et al., 2017).

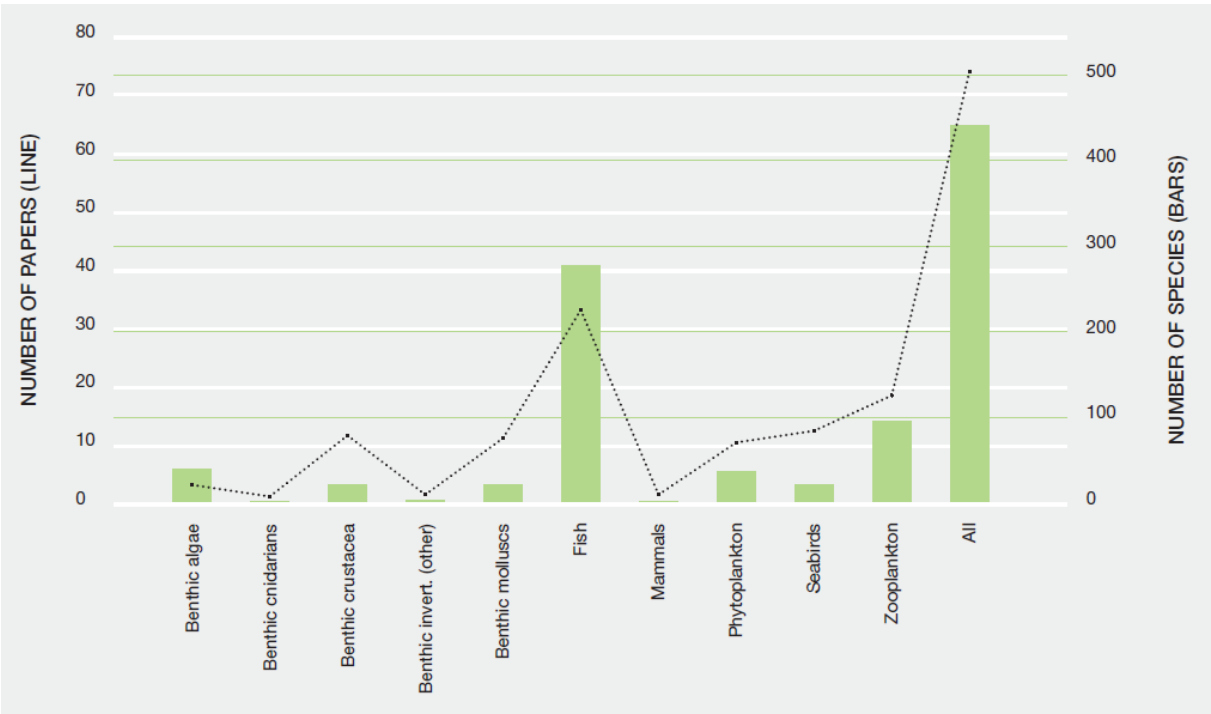


Figure 3.59: Number of papers examining past and current trends in marine communities and ecosystems (total 73) in the Atlantic. The total number of species examined (total 440) in these papers (per taxonomic group) is indicated by the bars. Data extracted from raw data compiled by Poloczanska et al. (2013).

Marine microbes may represent more than 90% of the ocean’s biomass, are the major drivers of its biogeochemical cycles (Danovaro et al., 2017), and can be found in the whole water column up to 2,000 metres below the seafloor. Although there has been an exponential increase in research on marine archaea, bacteria and viruses, and evidence that archaea and viruses may increase in importance with depth (Danovaro et al., 2015) their biodiversity and functioning is still largely unknown.

At least 7,000 species of lichens are known to occur in Europe (excluding Russia), while across the whole of Europe and Central Asia only five lichen species have been assessed in the IUCN Red List and have known conservation status (IUCN, 2017b).

Less than 10% of all species of vascular plants known to occur in the region have been assessed by the IUCN Red List (2,483 species for an estimated >30,000 for the region)(IUCN, 2017c). Among those assessed, 46.2% have unknown population trends. These also include species of conservation concern, such as 20% of the species included in the European Red List of Vascular Plants; (Bilz et al., 2011b). These knowledge gaps are caused by lack of field data, difficulties in accessing data for some countries, and uncertain taxonomy. Processes threatening vascular plants are also unknown for several species.

The number of fungus species in Europe exceeds 75,000, 15,000 of which are macrofungi (Senn-irlet et al., 2007). Currently there are no regional or continental data on status and trends of fungi.

We were unable to assess status and trends in diversity, biomass and community composition of soil and freshwater micro-organisms: Protozoa, Bacteria, Rotifera, Nematoda, Tardigrada, despite the key role of these organisms in soil formation, nutrient and carbon cycling, and water retention (Orgiazzi et al., 2016).

Relationship between biodiversity and ecosystem function and services

13052 For some ecosystem services, there is insufficient data to evaluate the relationship between
13053 biodiversity and ecosystem service provision. For example, the effects of fish diversity on fisheries yield
13054 and the effects of biodiversity on flood regulation are inconclusive (Cardinale et al., 2012). Additionally,
13055 ecosystem services provided by taxa other than plants are only beginning to be studied. Finally, the
13056 majority of studies reviewed focused on taxonomic diversity at the community level (i.e. species
13057 richness or diversity), rather than on intraspecific, functional phylogenetic diversity.

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4 Chapter 4: Direct and indirect drivers of change in biodiversity and nature's contributions to people

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17200 **Executive Summary**

17201 **The major direct anthropogenic drivers – natural resource extraction, land-use change, pollution,**
 17202 **climate change and invasive alien species – all strongly impact on biodiversity and nature’s**
 17203 **contributions to people in Europe and Central Asia, posing substantial risks for nature and human**
 17204 **well-being (*well established*) (4.2.1).** Direct drivers act independently and in combination, amplifying
 17205 and altering their context-specific individual and combined effects on biodiversity and nature’s
 17206 contributions to people (*well established*) (4.2.3, 4.9.1). For example, the impacts of climate change
 17207 are considerably exacerbated by adverse land-use changes. Direct drivers also impact each other
 17208 through different feedback systems and alter driver trends (*established but incomplete*) (4.9.1).
 17209 Indirect drivers – institutional, economic, demographic, cultural & religious and scientific &
 17210 technological – interactively determine the trends and impacts of direct drivers (*well established*)
 17211 (4.2.3).

17212 **The belief that further GDP growth will facilitate sustainable development is a deeply rooted cultural**
 17213 **driver, especially evident in Western and Central Europe, calling for smart, inclusive and sustainable**
 17214 **growth. However, this requires an absolute decoupling between GDP growth and degradation of**
 17215 **biodiversity and nature’s contributions to people which has not generally been observed**
 17216 **(*established but incomplete*).** Such decoupling is theoretically possible but would require a radical
 17217 change in policies and tax reforms at the global and national levels (4.3.1, 4.3.2, 4.3.4). Domestic
 17218 material consumption has increased in almost all European Union countries since the year 2000
 17219 (except for the economic contraction following the financial crisis in 2008), supported by growth-
 17220 oriented policies (4.4.4.2). There is some evidence that human wellbeing does not increase further
 17221 once a certain income threshold has been reached. Indeed, the sustainability challenge is to decouple
 17222 quality of life (wellbeing) from environmental degradation and pay less attention to GDP (*unresolved*)
 17223 (4.3.2, 4.3.4). Policies for resource efficiency have been implemented, but the tax system continues to
 17224 impede recirculation and resource efficiency and hence transitions towards a “green economy”. For
 17225 example, the total revenue from environmental taxes in the EU-28 in 2014 was only 2.5% of gross
 17226 domestic product (GDP), or 6.3% of the total revenues derived from all taxes and social contributions.
 17227 These proportions have decreased since 2002, from 2.6 % and 6.8 %, respectively (*well established*)
 17228 (4.3.2).

17229 **Demography as an indirect driver varies significantly between the subregions, with a dramatic**
 17230 **population decrease projected for Central Europe (*established but incomplete*).** Urban development
 17231 **will continue to affect natural and semi-natural rural land in large parts of Europe and Central Asia.**
 17232 The population of Europe and Central Asia, 910 million, is stable, but a dramatic population decrease
 17233 in Central Europe (excluding Turkey) is projected until 2050, from 123 to 104 million, due to currently
 17234 low fertility rates and high emigration rates (4.3.3). On-going rapid urbanization as people move from
 17235 rural areas into cities in Central and Eastern Europe and in Central Asia is fuelled by the deterioration
 17236 of livelihoods in rural areas (4.3.3 and 4.5.6). The consequent urban development results in both urban
 17237 sprawl and rural land abandonment. In Western Europe, urbanization occurs increasingly as people
 17238 move from inland areas to coastal cities, which puts further pressure on estuaries and other coastal
 17239 ecosystems (*well established*). There is a high potential for migration from Turkey and Central Asia to
 17240 Eastern and Central Europe in the coming decades. Armed conflicts have profound effects on
 17241 migration; for example, Turkey recently received (by March 2016) over 3 million refugees from Syria,
 17242 Iraq and Afghanistan. These large migrations may have important effects on other drivers of
 17243 biodiversity change (*established but incomplete*) (4.3.3).

17244 **Conventional intensification of agriculture and forestry has resulted in habitat loss, fragmentation,**
 17245 **and degradation and has negative impacts on biodiversity and nature’s contributions to people (*well***

established) (4.5.1, 4.5.2, 4.5.3). Intensification of agriculture has resulted in conversion of natural and semi-natural habitats on fertile landscapes, with severe negative impacts on biodiversity (*well established*) (4.5.1, 4.5.2, 4.5.3). In marginal lands, the side-effect of agricultural intensification has been the degradation and abandonment of traditionally managed semi-natural habitats and cultural landscapes that support high biodiversity and provide the magnitude of nature's contributions to people (*well established*) (4.5.1, 4.5.2, 4.5.5). Despite agri-environmental schemes and other mitigation measures, conventional intensive agriculture is jeopardizing sustainable land management, biodiversity, and food production (*established but incomplete*) (4.5.1, 4.5.2). Measures including ecological restoration, sustainable approaches to agriculture, e.g. ecological infrastructure that harness nature's contributions to people and inclusion of indigenous and local knowledge, have mitigated some of the adverse effects of intensive agriculture and represent opportunities to simultaneously secure diverse nature's contributions to people and conservation of biodiversity (*established but incomplete*) (4.5.1, 4.5.2).

Production of forest biomass for energy purposes and intensification of forest management have negative impacts on biodiversity and soil quality, as well as an array of material and non-material contributions from nature. The trade-offs between increasing intensity of forestry and delivery of diverse nature's contributions to people are recognized as a major challenge for forestry in Europe and Central Asia. Additionally, there is continuous logging in intact forest landscapes across the region (*established but incomplete*) (4.5.3). Environmental NGOs have played a key role in the adoption of forest certification schemes, which have reduced "wood mining" of remaining intact forests and have led to the inclusion of biodiversity conservation criteria and indicators in intensive forest management systems (*well established*) (4.5.2, 4.5.3).

Abandonment of intensively managed agricultural land has been widespread across Europe and Central Asia (*well established*). However, a comprehensive assessment of the effects of this process on biodiversity and nature's contributions to people is limited by knowledge gaps. In the European Union, cropland area has decreased by almost 1.2 million hectares in recent decades and largely been replaced by forested and urban areas (4.5.2, 4.5.4). Enlargement of the European Union to Central Europe and implementation of the European Union Common Agricultural Policy in new member States have resulted in the reconversion of some of this abandoned farmland to intensive agriculture – a trend that is likely to continue. Eastern Europe and Central Asia are and will remain hotspots of agricultural land abandonment (*well established*) (4.5.2). This has resulted in substantial reduction in livestock, and decline in crop production in these subregions. With the economic recovery and increasing domestic and foreign investments in agriculture after the year 2000, re-cultivation of some abandoned croplands began, particularly in the agriculturally favourable black soil regions in the south of European Russia, Ukraine and northern Kazakhstan (4.5.2, 4.5.3).

Abandonment of extensively managed traditional land-use systems, and loss of associated indigenous and local knowledge and practices, has been widespread in Europe and Central Asia (*well established*) (4.5.5). Cessation of traditional land use has led to loss of semi-natural habitats which support biodiversity of high conservation value (*well established*) (4.5.1). Loss of traditionally managed semi-natural habitats, especially grasslands, has resulted in decline and loss of associated biodiversity and ecosystem functions. Demographic trends, including urbanization, continue to diminish indigenous and local populations, with concomitant negative impacts on traditional land-use knowledge, culture and identities (*established but incomplete*) (4.5.5). In Europe and Central Asia, production-based subsidies driving growth in agricultural, forestry and natural resource extraction sectors tend to exacerbate conflicting land-use issues, often impinging on available territory for traditional users (*established but incomplete*) (4.5.5). In some areas, traditional practices are maintained to a certain extent, and traditional ecological knowledge is adapting to new ecological and

17293 socioeconomic conditions. Maintenance of traditional land use and lifestyles in Europe and Central
 17294 Asia is strongly related to institutional adequacy and economic viability. Traditional land uses and
 17295 knowledge are becoming increasingly recognized for their value in solving problems related to
 17296 biodiversity conservation and the sustainable use of natural resources and ecosystems (*established*
 17297 *but incomplete*) (4.5.5). The growth of green tourism and demand for products derived from traditional
 17298 practices and the availability of subsidies for traditional land uses are important factors in ensuring the
 17299 economic viability of indigenous peoples and local communities (*well established*) (4.5.5).

17300 **Protected areas have enormous importance for biodiversity conservation, and the area under**
 17301 **protection has been constantly expanding during recent decades across the region (*well established*)**
 17302 **(4.5.4).** In Europe and Central Asia, the total coverage of areas declared as protected is 10.2%, with
 17303 13.5% of the terrestrial area and 5.2% of the marine area being protected. Natura 2000 in the European
 17304 Union represents a systematic effort to develop new protected areas (4.5.4). Measures to improve
 17305 environmental status within conservation areas combined with landscape-scale approaches that
 17306 improve matrix quality for native biodiversity are needed (*established but incomplete*) (4.5.1.7). The
 17307 prioritization and implementation of adequate legal frameworks for protected area development has
 17308 largely been driven by the adoption of international agreements, as well as increasing public
 17309 environmental awareness. The perceived trade-offs with economic development goals, however, have
 17310 in many cases delayed the development of, or weakened, adequate nature conservation policies. The
 17311 inadequacy of institutions in navigating local resistance to protected areas and regulating the negative
 17312 impacts of conflicting land uses outside of protected areas poses important problems for biodiversity
 17313 conservation. Environmental NGOs have had an important impact in building public awareness of the
 17314 role of nature protection, leading to shifts in consumer preferences and political priorities.
 17315 Additionally, Europe and Central Asia is unfortunately the arena for a number of recent and current
 17316 armed conflicts. Armed conflict has many deleterious effects on protected areas, including multiple
 17317 direct and indirect environmental impacts, diversion of economic resources from protected area
 17318 budgets, loss of institutions and human resources, and interruption of long-term monitoring. There is
 17319 considerable evidence that protected areas alone cannot prevent global biodiversity loss (*well*
 17320 *established*) (4.5.4).

17321 **Within the present institutional framework, fishing, hunting, and mining pose considerable threats**
 17322 **to biodiversity (*well established*). Depletion of local mineral and fish stocks are disguised by global**
 17323 **trade, which delays effective responses, and harmful subsidies exacerbating unsustainable**
 17324 **extraction levels (*established but incomplete*).** Fossil fuels and rare earth minerals are the largest
 17325 contributors to GDP in Central Asia and the volume of coal mined has doubled in the last decade. The
 17326 mineral extraction industry in Central Asia has been driven by trade liberalization and increasing world
 17327 market prices (*well established*) (4.4.4.2). Demand for fish in the European Union continues to exceed
 17328 the sustainable yield and an increasing proportion of fish is imported. In a closed market economy, the
 17329 local shortage of material contributions to people due to excessive use would increase prices, drawing
 17330 attention to the shortage and the reasons for it. However, in a global economy these feedbacks (price
 17331 signals and awareness) are often masked by substitution. For example, the shortage of cod in Europe
 17332 has partly been substituted by cod and other white fish from other regions (4.4.1). The more successful
 17333 globalization and substitution becomes, the longer the delays between declining material
 17334 contributions to people, e.g. fish stocks, within one region, and policy responses in this region to
 17335 correct that decline (*established but incomplete*) (4.2.5, 4.4.1). Institutional drivers have changed, e.g.
 17336 the European Union's Common Fisheries Policy, but economic drivers have not (4.3.1, 4.3.2, 4.4.1.3).
 17337 Inefficiently low prices of fish are further lowered by harmful subsidies and technological drivers, which
 17338 result in high harvest levels despite declining stock. Europe, mainly the European Union and Russia,

17339 continue to pay about 6 billion USD annually in capacity-enhancing (harmful) fishing subsidies (*well*
17340 *established*) (4.4.1.3).

17341 **Despite effective regulations for some forms of pollution, this direct driver still poses major threats**
17342 **to biodiversity, nature's contributions to people and human health (*well established*). The drivers of**
17343 **pollution are mainly economic, i.e. effects of industrialization and globalization, including**
17344 **conventional intensive agriculture and increases in transportation (*well established*).** Pollution is also
17345 increased by institutional drivers that foster adverse technological development and the cultural belief
17346 that a prosperous life must entail more material consumption (*unresolved*). Pollution is a function of
17347 the industrial development model (4.6.6) and in general correlated to GDP (4.3.2) (*established but*
17348 *incomplete*). However, some pollution problems such as acidification and eutrophication of terrestrial
17349 ecosystems have been decreasing in Western and Central Europe since 1990, from 30% and 78%,
17350 respectively, of areas exceeding critical pollutant loads of sensitive ecosystems, to 3% and 55%,
17351 respectively. This has mainly been accomplished by regulations (*well established*) (4.6.1, 4.6.3).
17352 Phosphorous and nitrogen (except ammonia) pollution is decreasing in Europe but, partly due to time
17353 lags, many terrestrial systems and a large proportion of lakes and rivers in Western and Central Europe
17354 continue to be negatively affected (*well established*) (4.6.1, 4.6.2). Although marine and coastal
17355 eutrophication has decreased, the number of marine dead zones due to oxygen depletion resulting
17356 from nutrient and organic pollutants has increased markedly (*established but incomplete*) (4.6.1,
17357 4.6.2). Overall, there is evidence that pollution particularly negatively affects freshwater and marine
17358 biodiversity and water quality across Europe and Central Asia (*well established*). Global sales by the
17359 chemical industry doubled between 2000 and 2009 and continue to increase. Due to synergistic or
17360 “cocktail” effects, substances present in concentrations below recognized health threshold values can
17361 still be toxic, leading, for example, to human hormone disruption (*well established*) (4.6.4). Two kinds
17362 of pollution are increasing rapidly: plastic debris and microplastics affecting a wide array of marine
17363 organisms; and artificial light at night affecting terrestrial, aquatic and marine ecosystems (*established*
17364 *but incomplete*) (4.6.5).

17365 **There is strong evidence that the climate of Europe and Central Asia is changing towards warmer**
17366 **temperatures and regionally changed precipitation (*well established*) (4.7.2.1, 4.7.2.2), with**
17367 **generally drier summers in the southern and wetter winters in the northern parts of the region and**
17368 **increasing risk and amplitude of extreme climatic events such as droughts and storms (*established***
17369 ***but incomplete*) (4.7.2.2, 4.7.2.5).** Evidence that climate change impacts biodiversity and nature's
17370 contributions to people is emerging rapidly, and climate change is likely to become one of the most
17371 important drivers in the future, especially in combination with other drivers (*established but*
17372 *incomplete*) (4.9.2.2). The temperature will increase in the next decades and most units of analysis
17373 (biomes and land cover types) will experience an average warming between 1 and 3 °C by 2041-2060
17374 relative to 1986-2005, with larger increases for northernmost biomes such as snow and ice dominated
17375 ones and tundras (*well established*) (4.7.1.2). Precipitation patterns are projected to change across
17376 Western and Central Europe: drier climates and increased drought risk in their south-west, no change
17377 or increased precipitation in their north-west, while trends for Eastern Europe and Central Asia are
17378 ambiguous (*established but incomplete*) (4.7.2.2). Effects on biodiversity and nature's contributions to
17379 people vary according to the ecosystem itself, in particular depending on whether productivity is
17380 precipitation-, radiation- or temperature-limited. Climatic warming and precipitation change are
17381 driving shifts in seasonal timing, growth and productivity, species ranges and habitat occupancy with
17382 impacts on biodiversity, agriculture, forestry, and fisheries (*well established*) (4.7.1.1). Knowledge of
17383 the underlying processes and mechanisms suggests that many species will not be able to respond,
17384 migrate or adapt fast enough to keep pace with the projected rates of change in mean climate
17385 conditions, threatening ecosystem functioning and livelihoods (*established but incomplete*) (4.7.1.1.2).

17386 Across Europe and Central Asia, increased drought results in decreased primary productivity, increased
 17387 net carbon flux to the atmosphere, nutrient leaching from terrestrial systems and algal blooms,
 17388 biodiversity loss, and decreased water quality in aquatic systems (*established but incomplete*) (4.7.1.1).
 17389 The fifth assessment report of the Intergovernmental Panel on Climate Change established that
 17390 economic growth is the main driver of greenhouse gas emissions and hence climate change in Europe
 17391 and Central Asia (*well established*) (4.7.3). From 1970–2010, economic growth has been only partially
 17392 offset by improvements in the energy intensity of the economy and the emissions intensity of energy
 17393 production, and policies have proved insufficient in influencing infrastructure, technological, or
 17394 behavioural choices at a scale that curbs the upward greenhouse gas emissions trends (*well*
 17395 *established*) (4.7.3). Per capita emissions vary widely, depending on geography, income, lifestyle, and
 17396 the available energy resources and technologies, leading to differences in climate footprints within
 17397 Europe and Central Asia (*established but incomplete*) (4.7.3).

17398 **Evidence is emerging that indirect climate change effects, such as increased fire and flood risks and**
 17399 **loss of permafrost are affecting biodiversity and nature’s contributions to people in Europe and**
 17400 **Central Asia (*well established*) (4.7.1.3).** Increased precipitation, especially in winter, will result in
 17401 increased flood risk in the northern parts of Western and Central Europe (*established but incomplete*)
 17402 (4.7.2.1). Floods are a serious hazard to people, and increase erosion, water turbidity and
 17403 eutrophication, impacting freshwater provisioning (*established but incomplete*) (4.7.1.2). Increased
 17404 fire risk is projected across large parts of Western and Central Europe (*established but incomplete*),
 17405 while projected increases in fire danger for Eastern Europe and Central Asia are uncertain. Near-
 17406 surface permafrost extent at high northern latitudes is projected to decrease by between 37% (RCP2.6)
 17407 and 81% (RCP8.5) by the end of the 21st century, (*established but incomplete*). In Arctic and alpine
 17408 regions, permafrost melting may lead to large greenhouse gas emissions, and short-term heat waves
 17409 negatively impact productivity and may result in reduced food availability for wildlife and livestock
 17410 (*unresolved*). Climate change further leads to ocean acidification, sea level rise and changes in ocean
 17411 stratification, generally resulting in biodiversity loss, reduced growth and productivity and hence
 17412 impaired fisheries and increased release of CO₂ to the atmosphere (*established but incomplete*)
 17413 (4.7.1.3).

17414 **Invasive alien species have increased in number and for all taxonomic groups across all subregions**
 17415 **of Europe and Central Asia and this has severe effects on biodiversity and nature’s contribution to**
 17416 **people (*well established*). For Eastern Europe and Central Asia, the rate of invasion has been less**
 17417 **severe than in Western and Central Europe, but is expected to increase at a rate that strongly**
 17418 **depends on GDP development (*established but incomplete*) (4.8.1, 4.8.2).** Rates of increase in
 17419 numbers of invasive alien species are strongly correlated with introduction rates. Introduction rates of
 17420 alien species are strongly related to trade networks and have increased dramatically over the last 200
 17421 years in all environments (terrestrial, freshwater and marine), with 37% of first records reported from
 17422 1970–2014 (*well established*). Invasive alien species are affected by interactions with other drivers of
 17423 change such as land-use change and climate change (*established but incomplete*). The invasion process
 17424 (transportation, introduction, establishment and spread) is influenced by economic factors. Major
 17425 pathways of introduction in Europe and Central Asia include horticulture and ornamental trade,
 17426 accidental transportation, creation of commercial paths such as canals, and tourism (*well established*).
 17427 International, national and sub-national legal instruments targeting invasive and alien species have
 17428 been developed in Western and Central Europe but are currently lacking in Eastern Europe and Central
 17429 Asia. In addition, proactive educational outreach programs as well as trans-boundary legal instruments
 17430 targeting major introduction pathways have shown promising potential for improved prevention and
 17431 earlier detection of invasive alien species (*well established*). However, Aichi Biodiversity Targets 5 and
 17432 9 are unlikely to be achieved for Europe and Central Asia because of ongoing habitat conversion and

17433 fragmentation (Target 5) and because invasive alien species are not adequately controlled and are still
17434 increasing in numbers (Target 9) (*established but incomplete*) (4.5.1, 4.8.2). Invasive alien species
17435 generally tend to have negative effects on biodiversity and nature's contributions to people. However,
17436 their magnitude and direction vary among types of impact, taxa and environments (*well established*)
17437 (4.8.1).

17438 **In addition to immediate effects, the individual and combined effects of natural resource extraction,**
17439 **land-use change, climate change, diffuse pollution and invasive alien species can have chronic,**
17440 **prolonged and delayed impacts on biodiversity and the provision of nature's contributions to**
17441 **people, due to considerable time-lags in the response of ecological systems (e.g. extinction debt,**
17442 **colonization time-lags) (*well established*) (4.9.1).** For example, species extinctions due to habitat area
17443 loss and increasing fragmentation can take decades or centuries due to the slow intrinsic dynamics of
17444 populations of many species (*well established*) (4.5.1, 4.9.1). Climate change can have delayed effects
17445 on change in species distribution patterns and development of species assemblages under new
17446 conditions because of time lags in population response and migrational lags (*established but*
17447 *incomplete*) (4.7.1.1.2, 4.9.1). Nutrient pollution continues to influence terrestrial and aquatic
17448 ecosystems for decades after external inputs are reduced (*well established*) (4.6.1). Considerable
17449 delays occur between the initial introduction of alien species and their possible spread as invasive alien
17450 species (*well established*) (4.8.1). Such time-lags introduce uncertainty and can lead to serious
17451 underestimation of the effects of current direct drivers on biodiversity and nature's contributions to
17452 people. Decisive and proactive policies would avoid future loss of species and nature's contributions
17453 to people (*established but incomplete*) (4.5.1, 4.6.1, 4.7.1, 4.8.1, 4.9.1).

17454

4.1 Introduction

4.1.1 Aim of the chapter

The aim of this chapter is to assess evidence of the status and trends of the drivers that affect biodiversity and nature's contributions to people. There are three wider categories of nature's contributions to people: regulating, material and non-material contributions, that are similar to, but not identical to classifications of ecosystem services (see Chapter 1). Ecosystems are dynamic interacting networks of animals, plants, fungi, and microorganisms, above and below ground and water-surfaces. These biodiverse networks of interacting organisms respond to a set of environmental factors such as climate, soil, or water conditions. Social-ecological systems also include human activities (direct drivers) that modify almost all of these ecosystem interactions and environmental factors, and the underlying societal (indirect) drivers of these activities. It is thus important to understand the status and trends of the direct and indirect drivers that affect biodiversity, including ecosystems and, thereby, affect nature's contributions to people.

4.1.2 Scope and organization of the chapter

This chapter focuses on the effects of drivers on biodiversity and nature's contributions to people and thereby only indirectly on quality of life, which is dealt with in greater detail in Chapter 2. Section 4.1 describes the scope of the chapter, the role of drivers in the IPBES conceptual framework, and methodological approaches. Section 4.2 explains which system of "drivers of change" is addressed in this assessment. We compare and specify concepts which have been used in earlier assessments to justify the choice of direct and indirect drivers, including their sub-categories. The section also discusses the importance of the temporal and spatial variability of drivers and interregional flows. Section 4.3 assesses major trends in the five individual indirect drivers in Europe and Central Asia. Indirect drivers are then assessed for each direct driver in the subsequent sections.

Chapters 2 and 3 of the IPBES Regional Assessment for Europe and Central Asia identified strong evidence that biodiversity and nature's contributions to people are declining, and that natural resource extraction, land-use change, pollution, climate change, and invasive alien species are the main direct drivers of these changes. Sections 4.4 to 4.8 assess five direct drivers, one in each section. We first assess the overall effects of the direct drivers on biodiversity and nature's contributions to people in Europe and Central Asia (please note that the specific effects of direct drivers on specific taxa and each unit of analysis (i.e. types of ecosystems, see Chapter 1) are the subject of Chapter 3). After establishing the general effects of the direct drivers, we provide an assessment of the trends in each direct driver and sub-categories of the drivers within the different regions and units of analysis over the recent past (20-40 years) and projected into the future (50-85 years). We use the word "projected" rather than "predicted" because in the medium long run, predictions of the future are not possible. Then we assess the indirect drivers that underpin the direct drivers of changes in biodiversity and nature's contributions to people. As described below, the indirect drivers interact considerably and are often context specific, and therefore they should not be assessed in isolation. We use causal loop diagrams (CLDs) to illustrate some of the complex interactions and causal relationships affecting each driver.

Section 4.9 synthesizes the main findings for the overall trends in, and impacts of, drivers on biodiversity and nature's contributions to people across subregions and biomes (the unit of analysis) in the past and projected into the future. For direct drivers, this synthesis is based on an assessment of all sub-categories of drivers and their compound impacts. For indirect drivers, the synthesis in 4.9.3 is based on the empirical sections.

17499

17500

4.1.3 Driver as a concept

17501 The distinction between “indirect” and “direct” drivers was popularized by the Millennium Ecosystem
 17502 Assessment (MA, 2005b) and this classification still dominates the debate on ecosystem change (e.g.
 17503 Henrique M. Pereira et al., 2010). The older DPSIR terminology (drivers, pressures, states, impacts,
 17504 responses), popular in Western Europe (EEA, 1995), divided drivers into “driving forces” and
 17505 “pressures”, with the former corresponding to indirect drivers and the latter corresponding to direct
 17506 drivers of the Millennium Ecosystem Assessment (Tzanopoulos et al., 2013).

17507

17508

4.1.4 Natural and anthropogenic drivers

17509 Analytically it is sometimes difficult to distinguish whether an element (process, factor, driver) belongs
 17510 to the natural or the human system. Biogeophysical processes and factors such as volcanic eruptions,
 17511 tsunamis, El Nino, solar radiation, or storms, are natural and they influence all elements of life on earth.
 17512 These “natural drivers” and extreme events are not assessed in this chapter. Our analysis is limited to
 17513 drivers linked to human activities, and are therefore considered anthropogenic or at least
 17514 anthropogenically influenced drivers. In this context, direct drivers are the result of human interactions
 17515 with natural processes that directly act upon biodiversity, including ecosystems, by altering natural
 17516 processes, while indirect drivers are structures and processes governing the human interactions,
 17517 thereby influencing direct drivers. So, while we would consider climate and weather, habitats, and
 17518 species’ dispersal and range dynamics to be natural processes, anthropogenic climate change, land-
 17519 use change and invasion by alien species reflect the human influence on climate, land use and
 17520 biodiversity dynamics, respectively.

17521 However, to unequivocally disentangle natural variability from anthropogenic drivers is often difficult.
 17522 Human impacts now affect more than half of the Earth’s ice-free terrestrial surface (Ellis, Klein
 17523 Goldewijk, Siebert, Lightman, & Ramankutty, 2010) and humans now exert a dominant influence on
 17524 key Earth system processes and on ecosystem change and biodiversity loss (Newbold et al., 2015, 2016;
 17525 Steffen, Crutzen, & McNeill, 2007). This has led to the coining of a new geological epoche, the
 17526 “Anthropocene” (see Crutzen, 2002). While there is debate over when, exactly, the transition from the
 17527 Holocene to the Anthropocene occurred, it is often set to when human impacts took over as a
 17528 dominating influence on the earth system processes, early in the 20th century (see Steffen et al., 2007).
 17529 Human influences were also present prior to this transition, and the nature and magnitude of the
 17530 impacts through time and especially in the more distant past 3,000-8,000 years ago, are still debated
 17531 (Ruddiman, 2013; Scott, Bowman, Bond, Pyne, & Alexander, 2014). This assessment takes a pragmatic
 17532 approach to this challenge, focusing on assessing the impacts of major modern (i.e., post-industrial)
 17533 anthropogenic drivers relative to the more-or-less human affected pre-industrial landscapes (see also
 17534 Nybø et al., 2017). **Box 4.1** exemplifies the analytical challenges in distinguishing between “natural” or
 17535 “anthropogenic” factors in the past through the example of forest fires.

17536 **Box 4.1: Natural or human control over forest fires in northern Europe?**

17537 It is sometimes difficult to clearly separate natural (Earth system) and anthropogenic (human activities) drivers
 17538 and land use often interacts with natural processes. A typical example is the occurrence of forest fires in the
 17539 northern boreal forests of Europe and Central Asia. .

17540 Long term chronologies based on charcoal in sediments, covering 10,000 years after the last glaciation
 17541 (Holocene), suggest climate has been the main governing factor for fire regimes (Carcaillet, Bergman, Delorme,
 17542 Hornberg, & Zackrisson, 2007). Although humans have been present during most of the Holocene (based on

carbon-14 dated archaeological features) on millennial scales, fire history does not show any relationship to human presence in these remote landscapes. Hence, Carcaillet et al. (2007) suggest that natural processes have been decisive for the long-term fire pattern. It has also been argued, based on dendrochronological (tree-ring based) reconstructions that years with many large fires may be controlled by the climate (Drobyshev, Bergeron, Linderholm, Granström, & Niklasson, 2015).

However, several dendrochronological reconstructions (with high temporal resolution) show clear links between fire patterns and human presence in the landscape during most of the last millennium (Granström & Niklasson, 2008; Wallenius, Kuuluvainen, & Vanha-Majamaa, 2004). Granström and Niklasson (2008) depict several fairly distinct periods of human influence on forest fires. In the earliest stage (during the millennia after the deglaciation), prehistoric moose hunters may have used fire to open the landscape in order provide better grazing conditions.

When the Sami people in the northern parts of Europe and Central Asia began changing from hunting reindeer to reindeer husbandry in the 17th century (T. Hahn, 2000), they had an incentive to ensure that ground vegetation conditions (lichens) were suitable for reindeer. Since only an estimated 1 % of the stands naturally burned every year (Zackrisson, 1977) and the repeated burning was important to create open all-aged tree stands optimal for maintaining lichen cover on the ground (A.-L. Axelsson & Östlund, 2001; Berg, Östlund, Moen, & Olofsson, 2008; Östlund, Zackrisson, & Axelsson, 1997), fires were probably an important management practice also for the early forms of reindeer husbandry. When commercial forestry was established from the mid-1800s, it resulted in increasingly effective fire suppression. Dense monoculture forests and lack of fires have reduced the extent of lichen covered areas in Sweden by 70 % since 1955 (P. Sandström et al., 2016).

On the border between current Finland and Russia there is an apparent mismatch between predicted lightning ignition frequency and observed fire history, suggesting that as far back as a millennium ago, a very small human population may have played a role in the fire history of remote boreal forests (Wallenius, Kauhanen, Herva, & Pennanen, 2010). This leads to the conclusion that potentially the boreal forests that developed after the glaciation have to quite some extent been formed by human presence in the landscape.

End of Box 4.1

4.2 Drivers of change in biodiversity and nature's contributions to people

4.2.1 Direct drivers

The Millennium Ecosystem Assessment (MA, 2005b) distinguished five major classes of direct drivers of biodiversity change, namely habitat change, climate change, invasive alien species, over-exploitation and pollution (mostly nitrogen and phosphorous). Here, we largely follow this classification of direct drivers, although we use “natural resource extraction” instead of “over-exploitation, to avoid using value-laden terms (Table 4.1). However, we still use “over-fishing” since this is such an established term in contemporary global fisheries (Worm et al., 2006). Water extraction and fish harvesting are considered here as two sub-categories of natural resource extraction, not as two separate direct drivers as in Pereira et al. (2010). Here, we briefly describe the five categories of direct drivers including sub-categories, and explain what is summarized within each of these (see for an overview of all classes). None of the sub-categories is uniform in its expected impacts on biodiversity and nature's contributions to people, and we have, therefore, distinguished a number of further elements within sub-categories when analysing the available information for recent and projected future trends.

Table 4.1: Categories of direct drivers of change in biodiversity and nature's contributions to people. The five major categories are composed of two to six subcategories. More details for each sub-category are given in the text.

17588 **Natural Resource Extraction**

- 17589 ▪ Fishing
- 17590 ▪ Hunting
- 17591 ▪ Water use & desalination
- 17592 ▪ Mineral & fossil fuel extraction
- 17593

17594 **Land use change**

- 17595 ▪ Changes in agriculture
- 17596 ▪ Changes in forestry
- 17597 ▪ Changes in protected areas
- 17598 ▪ Changes in traditional land use
- 17599 ▪ Changes in urban development
- 17600

17601 **Pollution**

- 17602 ▪ Nutrient pollution
- 17603 ▪ Organic pollution
- 17604 ▪ Acidification
- 17605 ▪ Xenochemical & heavy metal pollution
- 17606

Climate Change

- Temperature change
- Precipitation change
- Sea-Level change
- Glaciers & permafrost
- Extreme events
- Marine circulation and deoxygenation
- Atmospheric CO₂ concentration

Invasive alien species

- Terrestrial
- Freshwater & Brackish
- Marine

17607 Natural Resources Extraction: For biotic resources extraction, we distinguish fishing and hunting.
 17608 Logging is treated as a sub-category of land-use change and therefore not included here. Gathering of
 17609 plants for human use (e.g. berries, mushrooms) is identified by IUCN as a threat to biodiversity
 17610 (Maxwell, Fuller, Brooks, & Watson, 2016a), but not assessed here. For the extraction of abiotic
 17611 resources, we distinguish water use & desalination, and mineral & fossil fuel extraction.

17612 Land-use change: Changes in five major land-use categories are assessed, namely: changes in
 17613 agriculture, forestry, protected areas, traditional land use and urban development.

17614 Pollution: Past assessments focused on pollution from nitrogen and phosphorus (MA, 2005a, 2005b).
 17615 In this assessment, we distinguish five main categories of pollutants, namely: nutrient pollution,
 17616 organic pollution, acidification, xenochemical and heavy metal pollution and “other” pollution
 17617 (including ground-level ozone, light and plastic pollution).

17618 Climate Change: This driver class has been studied prominently in recent IPCC reports, with regards to
 17619 both its current and projected future trends, and its expected impacts on terrestrial and marine
 17620 ecosystems (IPCC, 2013b, 2014a, 2014b). Here, we distinguish seven major sub-categories, namely:
 17621 changes in precipitation, temperature, atmospheric CO₂ concentrations, glacier and permafrost
 17622 extent, sea-level, extreme events, and marine ocean-atmosphere interchange.

17623 Invasive Alien Species: An alien species (also known as an exotic or introduced species) is a species
 17624 occurring in an area outside of its historically known natural range as a result of intentional or
 17625 accidental dispersal by human activities (CBD, 2011). Invasive alien species (IAS) are alien species
 17626 whose introduction or spread threaten biological diversity or that have other negative effects on
 17627 ecosystems, economy or society (CBD, 2011; Roy et al., 2014). In this report, we distinguish three major
 17628 categories of invasive alien species, namely: terrestrial, freshwater (including brackish waters), and
 17629 marine.

17630

4.2.1 Indirect drivers

We identify five categories of indirect drivers, adapted from Hauck et al. (2015) building on the MA (2005b) framework. Some scholars call indirect drivers “underlying drivers” (van Vliet, de Groot, Rietveld, & Verburg, 2015), “underlying causes,” “fundamental social processes” (Geist & Lambin, 2002), “categories of origin” or “key driving forces” (Brandt, Primdahl, & Reenberg, 1999). Hence, there are different attempts to conceptualize indirect drivers (**Table 4.2**). If indirect drivers are the underlying causes of, for example, land-use change or pollution, then the tangible results of human activities can be seen as direct drivers, or “proximate causes”. For example, for deforestation, proximate causes can include agricultural expansion, wood extraction or the extension of road infrastructure (Geist & Lambin, 2002). Indirect drivers do not directly impact biodiversity, but may have a direct impact on nature’s contributions to people, according to the IPBES conceptual framework. For example, some legal restrictions may reduce nature’s contributions to people to certain groups of people and some non-material contributions of nature are co-produced by people and nature (S. Díaz et al., 2015).

The literature on indirect drivers often treats land-use change as the dependent variable and gives less attention to its consequences for biodiversity and ecosystem services. Van Vliet et al. (2015) include “location factors” as an underlying (indirect) driver, consisting of accessibility, climate, topography, and soil quality (“EU” in **Table 4.2**). Similarly, Brandt et al. (1999) include “natural environment” (“UNESCO” in **Table 4.2**) as a key driving force, consisting of geomorphology, soil, climate and hydrology. Geist and Lambin (2002) also include “pre-disposing environmental factors” such as soil, topography and fragmentation mediating the underlying drivers (“IGBP-IHDP” in **Table 4.2**). Furthermore, they address biophysical and social triggers, which ecologists call “fast variables” or “disturbances”.

Table 4.2: Different categorizations of indirect drivers

UNESCO ¹	IGBP-IHDP ²	EU ³	MA 2005a	IPBES
Socioeconomic	Economic	Economic	Economic	Economic
Policy	Policy/Institutional	Institutional	Socio-political	Institutional
Culture	Cultural	Sociocultural	Cultural & religious	Cultural & religious
–	Demographic	Demographic	Demographic	Demographic
Technology	Technological	Technological	Science & Technology	Scientific & Technological
Natural environment	(Environmental factors)	Location factors	–	–

¹ Brandt et al. (1999); ² Geist and Lambin (2002); ³ van Vliet et al. (2015)

Based on Geist and Lambin (2002), we identify biophysical triggers including fires, droughts, floods and storms, and social triggers including revolution, social disorder, abrupt displacements, economic shocks, and abrupt policy shifts. These triggers emerge from indirect drivers and may have dramatic effects on direct drivers. The breakdown of the Soviet Union (M. Baumann et al., 2011; A. V. Prishchepov, Müller, Dubinin, Baumann, & Radeloff, 2013) and the nuclear accident of Chernobyl (Hostert et al., 2011) could not be foreseen, but led to widespread farmland abandonment and decreasing land-use intensity. From a policy perspective, it is important to understand both drivers and triggers, to “accept uncertainty, be prepared for change and surprise, and enhance the adaptive capacity to deal with disturbance” (Folke, Hahn, Olsson, & Norberg, 2005).

17665 Here, we use categories of indirect drivers similar to previous assessments and studies (**Table 4.2**).
 17666 However, the sub-categories of indirect drivers have been updated as outlined in **Table 4.3**.

17667 **Table 4.3: Categories of indirect drivers that underpin direct drivers of change in biodiversity and**
 17668 **nature's contributions to people. More detailed information about, and motivation for selecting the**
 17669 **sub-category under each main category is given in the text.**

Institutional	Economic
▪ Regulations	▪ Material intensity of GDP
▪ Institutional capacity	▪ Globalization
▪ Environmental policy integration	▪ Taxes and subsidies
▪ Political/armed conflicts	▪ Environmental fiscal reform
 Demographic	 Cultural & religious
▪ Population growth & density	▪ Public awareness, knowledge
▪ Urbanization	▪ Values, beliefs, social norms
▪ Migration	▪ Lifestyle, consumption
	▪ Social capital
 Scientific & Technological	▪ Cultural capital
▪ New technologies	
▪ Innovation	

17670
 17671 Institutional drivers: Legislation and regulations provide the institutional arrangements (formal
 17672 institutions, or legal framework) for all natural resource management. We refer to these as
 17673 “regulations”, to distinguish institutional drivers from informal institutions, which are mainly social
 17674 norms and therefore belong to cultural & religious drivers. Some regulations promote sustainable
 17675 natural resource management and governance to a greater or lesser extent. However, regulations
 17676 safeguarding biodiversity and nature's contributions to people may not be enforced or, if they are,
 17677 may not be effective. This depends on the institutional capacity, or the governability of the state, for
 17678 example to regulate the private/public sectors and to engage civil society (Breukers & Wolsink, 2007;
 17679 MA, 2005b). Important institutional drivers are those sector regulations that impact biodiversity and
 17680 nature's contributions to people, for example, energy, mining, conventional agriculture and forestry,
 17681 large-scale fisheries, and tourism. Improving or changing these sectoral policies to better account for
 17682 biodiversity and nature's contributions to people is sometimes called “mainstreaming” or
 17683 “environmental policy integration” (Nilsson & Persson, 2003), including consistent multi-level
 17684 governance (Malayang III, Hahn, & Kumar, 2006; Pahl-Wostl, 2009).

17685 The international discussion has lately emphasized the role of policy integration. For example, Strategic
 17686 Goal A of the Strategic Plan for Biodiversity 2011–2020 addresses “the underlying causes of biodiversity
 17687 loss by mainstreaming biodiversity across government and society” (CBD, 2010a). Hence, assessing
 17688 changes in institutional drivers can be framed regarding the extent to which countries and regions have
 17689 succeeded in environmental policy integration (mainstreaming). Institutional drivers are intertwined
 17690 with other indirect drivers. For example, since markets are influenced by legislation (Bromley, 1991),
 17691 global trade as an economic driver is largely the result of trade agreements, which are not always
 17692 consistent with international environmental regulations. Finally, the literature also refers to the role
 17693 of international collaboration as well as political or armed conflicts.

Economic drivers: Global GDP is expected to increase from about 50 trillion US\$ in 2005 to between 155 trillion (UNEP, 2012) and 300 trillion in 2050 (OECD, 2001). These figures diverge considerably and provide no information about how sustainable the growth of GDP is expected to be. Hence, we see material intensity of GDP, not GDP in itself, as a driver. Global trade increases demand for many nature's contributions to people and changes production and consumption patterns, and therefore ecosystem use, at local, national, and global levels. Economic drivers are strongly linked to institutional drivers, which govern production through regulations, taxes and subsidies, thereby influencing relative prices of, for example, fossil fuel versus renewable energy. Internalising external environmental costs may, however, be difficult due to its effects on global competitiveness. Hence, the environmental fiscal reforms called for by the United Nations Environment Programme to make the economy more efficient, must be seen in a global context.

Demographic drivers: This group includes population density and growth, urbanization and migration as well as ageing population (Hossman, Karsch, & Klingholz, 2008; Kroll & Kabisch, 2012). Human population growth is one of the most fundamental reasons behind all direct drivers.

Cultural and religious drivers: Public awareness and knowledge about environmental change are fundamental indirect drivers. Filtered by values, beliefs and social norms, public awareness exerts pressure on decision-making about the environment (G. C. Nelson et al., 2006). Culture conditions the individual's perceptions of the world, influences what he or she considers important, and suggests courses of action that are appropriate and inappropriate. Although culture is most often thought of as a characteristic of national or ethnic groups, our definition emphasizes the emergence of cultures within professions, organizations and gender, along with the possibility that an individual may be able to draw on or reconcile more than one culture (G. C. Nelson et al., 2006). Cultural values are materially manifested in lifestyles and consumption patterns. To enable transitions to sustainability, cultural drivers such as social capital may be mobilized by trust-building (Pretty, 2003).

Scientific and technological drivers: Technology is a major driver of economic growth, accounting for more than one third of the GDP growth in the US 1929-1980 (MA, 2005b) and similar effects might be expected in Europe and Central Asia. Technology also directly influences direct drivers in very tangible ways, for example in forestry, agriculture and fisheries, resulting in intensification of land uses (MA, 2005b). Technology can be seen as just a "tool", neither good nor bad. Its effects depend on how it is used and developed. For instance, new information and communication technologies might have the potential for both agricultural intensification and disintensification (Grimes, 2000). At the same time, the direction of technological development is a function of price relations, which in turn are influenced by institutions. For example, the "green" revolution has promoted fossil fuel derived inputs to replace natural inputs in agriculture (Perelman, 1972). With different institutions, technological innovations and development can increase resource efficiency and decoupling, being an integrated part of the transformation to a green economy and an important part of the development of the circular economy (European Commission, 2017b; UNEP, 2011). However, technological development resulting in resource efficiency may lower the price of the natural resource, which in turn may increase the consumption of this resource; this is called Jevons paradox or the rebound effect. Taxes on natural resources (e.g. an environmental fiscal reform) are needed to prevent the rebound effect (Polimeni, Mayumi, Giampietro, & Alcott, 2012).

4.2.2 Relationship between indirect and direct drivers

The previous section suggests that indirect drivers are intertwined and in combination influence direct drivers. The interaction among indirect drivers is highly complex, i.e. they are hard to trace back to a

single point of origin, and their impacts are often reciprocal and not unidirectional. Jointly, indirect drivers impact on direct drivers, which in turn also interact in the way they drive ecosystem change (Figure 4.1). For example, climate change affects the survival of invasive alien species, and land-use change can have feedback effects on climate. Knowledge about the effects of direct drivers on biodiversity and nature’s contributions to people increases public awareness and feedback to the underlying indirect drivers.

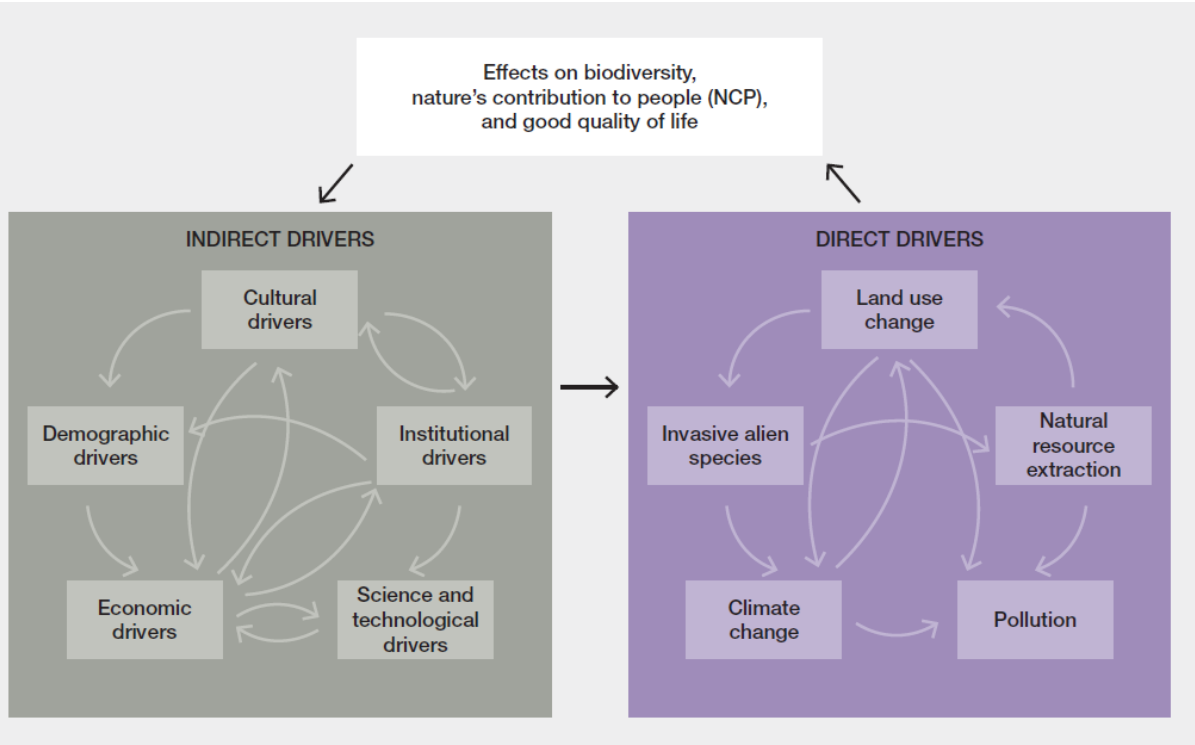


Figure 4.1: Illustration of multiple interactions among indirect and direct drivers within a specific context that have impact on biodiversity and nature’s contributions to people. The graph illustrates important links; more are possible. Knowledge and awareness of changes in biodiversity and nature’s contributions to people influence indirect drivers and make adaptations possible.

4.2.3 Spatial and temporal variability

Even though the major direct drivers are known, their specific effects and overall trends over time are not always easy to identify, quantify and assess. This is primarily due to their high spatial and temporal variability. Some drivers are local in nature (e.g., land-use change and point-source pollution of heavy metals or nutrients), while others are regional (e.g., ozone or atmospheric nitrogen pollution from combustion engines) or global (e.g., atmospheric CO₂ or sea-level rise). Some of these drivers affect all species and ecosystems more-or-less equally (e.g., radioactive pollution), while other drivers affect species and ecosystems very selectively (e.g., nitrogen deposition), and therefore often exert complex effects on biodiversity and nature’s contributions to people.

While the effect of some drivers is immediate (e.g. mining), others exhibit significant time lags in their effect on biodiversity and nature’s contributions to people. While climate and land-use change and invasions by alien species are steadily increasing, their full effect is often visible only much later, since the biodiversity and ecosystem response is slow. This has given rise to the terms invasion debt (Essi et al., 2011) or extinction debt (Dullinger et al., 2012; David Tilman, May, Lehman, & Nowak, 1994), to express the expected time lags until the full effects of drivers are realized. The many facets of climate

17766 change rarely affect species and ecosystems without delay, and the climate itself also lags behind the
17767 increase in greenhouse gas concentrations (IPCC, 2014a).

17768 While some effects are steadily shifting (e.g., sea-level rise), others are unstable and show high
17769 temporal variability. This is especially the case with climate, which includes changes in mean
17770 conditions, time course and extremes (such as heat-waves, drought, fire, floods or winds). The
17771 biological response can be linked to the changes in means, time courses and in extremes, and the
17772 responses can be gradual or they can be in the form of tipping points between alternative stable states
17773 (Barnosky et al., 2012; Hoegh-Guldberg et al., 2007), which can be irreversible.

17774

17775 4.2.4 Interregional flows

17776 Inter-regional flows include trade in agricultural commodities, fish and wood, which can be measured
17777 as human appropriation of net primary productivity (HANPP) (Krausmann et al., 2013). As a result of
17778 international and even interregional trade, and with the exception of northern parts of Western
17779 Europe, and Eastern Europe, Europe and Central Asia appropriates a larger amount of nature's
17780 contributions to people than it produces. Put differently, their ecological footprints exceed their bio-
17781 capacity (Global Footprint Network, 2017). Inter-regional trade of nature's contributions to people has
17782 consequences for local ecosystems in the exporting country, but also direct global effects. For example,
17783 in 2004, the deforestation embodied in final consumption within the EU-27 was 732,000 ha, which was
17784 about 10% of the world's annual deforestation (European Commission, 2013) (see also Section 2.2.4
17785 in this Volume).

17786 Besides these direct biophysical effects, interregional flows of nature's contributions to people also
17787 have profound effects on direct and indirect drivers of ecosystem change. First, the pressures on
17788 domestic and regional ecosystems can be reduced when nature's contributions to people are
17789 imported, i.e. when natural resource extraction, pollution and land-use change are "exported".
17790 Second, interregional flows may have repercussions for other sectors, sometimes referred to as
17791 telecoupling. For example, biofuel mandates in the European Union contributed to global food
17792 shortages in 2008 and subsequent civil unrest in other world regions (Liu et al., 2015).

17793 Inter-regional trade is justified in terms of economic efficiency. Differences in the market price of
17794 agricultural or forestry commodities, fish, and minerals can be seen as differences in scarcity, which
17795 are levelled out by trade, resulting in increased efficiency. However, if the external costs of production
17796 and trade are not taken into account, interregional trade may not enhance efficiency. Without
17797 interregional trade, a region consuming more than its biocapacity (or extraction of minerals) would
17798 experience increased physical scarcity which, in a market economy, would result in increasing prices.
17799 This price signal would, in turn, drive producers and consumers to search for substitutes. It would also
17800 raise public awareness of the scarcity, which could become a pressure for institutional change. Inter-
17801 regional trade offsets this price signal and thereby inhibits the feedbacks to economic and institutional
17802 drivers. This is the purpose of trade, not a side-effect, and it would not be a problem for nature or
17803 human quality of life if trade were based on sustainable harvest and extraction levels (Daly & Farley,
17804 2011).

17805 However, if harvest levels or the production methods of these goods are not sustainable, partly
17806 because external costs are not included in their price, then inefficient and unsustainable production of
17807 material contributions of nature are exacerbated by interregional trade. Policy failures such as
17808 inappropriate environmental regulations in producing countries, increase incentives to export these
17809 goods. Importing countries subsequently enjoy low prices and offsetting of scarcity. This "organized
17810 irresponsibility" (Beck, 2005) has not emerged by accident. On the contrary, export-oriented economic

growth has been a common growth strategy for many developing countries, supported by the World Bank and other international organizations. For example, unsustainably produced agricultural commodities such as soy, coffee, and palm oil have flooded the world market, resulting in low and fluctuating prices and thereby increased vulnerability in the producing countries (Adger, Eakin, & Winkels, 2009). In this way, global drivers of market integration become drivers of both local vulnerability and global unsustainability. In a sustainable world, global trade would not be a problem. However, in the contemporary world, unsustainable production methods in the producing countries are reinforced and scaled-up by short-term profits from trade and the lack of environmental regulations in present global and bi-lateral trade institutions (Daly & Farley, 2011).

Natural resource extraction of minerals and fish are also important interregional flows. Western and Central Europe import most of their mineral resources due to the depletion of their own resources, and high extraction costs partly due to environmental regulations (European Commission, 2014). Without cheap imported minerals, there would be pressure to increase recycling and substitution. However, interregional trade softens and delays these economic and institutional feedbacks. Similarly, the depletion of fish stocks in Europe and Central Asia has partly been met by supply of imported fish, preventing increases in the cultural drivers of prices and awareness, respectively. Both reduce public pressure for institutional responses (see Section 4.4.1.3).

4.2.5 Methodological approach

4.2.5.1 Effects of, and trends in, direct drivers

Each of the main five direct drivers (see Section 4.2.1) was assessed focussing on a set of sub-categories of these main driver categories. The literature was screened for effects of direct drivers on biodiversity and nature's contributions to people, and for trends of the recent past and of the projected future within Europe and Central Asia. Most weight was given to literature published after 2005, since earlier literature was largely covered by the Millennium Ecosystem Assessment. For some drivers (e.g. some aspects of natural resource extraction, land-use change, or biological invasions), there is less available information than for others, or it is only available for recent periods. To assess the trends in climate change drivers, more publications are available than for the other direct drivers, and also large databases of spatial data. While we did not perform primary analyses for this assessment, we assessed climate drivers through observational data and data from the CMIP5 (Coupled Model Intercomparison Project Phase 5) climate change simulations used in the IPCC AR5 WGI reports (IPCC, 2012, 2013a, 2013b) and extracted from the KNMI climate change atlas website (IPCC, 2012; van Oldenborgh, 2016). For historical climate data we used five data sets, namely: 1) GISTEMP (GISTEMP Team, 2015; J. Hansen, Ruedy, Sato, & Lo, 2010); 2) HadCRUT version 4.2.0.0 (Morice, Kennedy, Rayner, & Jones, 2012); and 3) NCDC MOST (P. Jones & Moberg, 2003; Peterson & Vose, 1997); 4) CRU TS 3.24 (Harris, Jones, Osborn, & Lister, 2014); and 5) GPCC V7 (Schneider et al., 2011). For future climates, we used data used in IPCCs AR5 (IPCC, 2013a, 2013b), using all four representative concentration pathway (RCP) scenarios, indicating levels of radiative forcing by greenhouse gases in the atmosphere), namely: RCP2.6, RCP4.5, RCP6.0, and RCP8.5. Higher numbers indicate a higher greenhouse gas effect and a higher level of change to the atmosphere and climate.

Status and trends of temperature and precipitation were extracted for the whole region and for its four subregions. Values for time series were averaged over land grid. Average historical trend estimates and projected future anomalies were calculated for each unit of analysis within each subregion. Spatial distributions of the units of analysis were derived from multiple datasets (see Chapters 1 and 3) (Figure 4.2). Average climate values were computed by overlaying units and

17856 subregions with climate data, and calculating mean values for summer (JJA) and winter (DJF). Time
17857 series were generated for 1950-2060 as anomalies relative to 1986-2005. As an indication of model
17858 uncertainty and natural variability, the time series of each individual model and scenario was included
17859 over the analyzed period (see **Figure 4.3** and IPCC (2013b) for more info). Future anomalies were
17860 estimated as 20-year means for the time period 2041-2060. Maps of projected trends were generated
17861 for Europe and Central Asia similarly to the IPCC AR5 WG1 Annex 1 (IPCC, 2013a), using the KNMI
17862 climate change atlas. Two representative concentration pathway scenarios were used to generate
17863 maps: scenario RCP 4.5 and 8.5 (IPCC, 2013b). Spatial averages over complex regions provide general
17864 trends, but may not explain the details for particular locations.

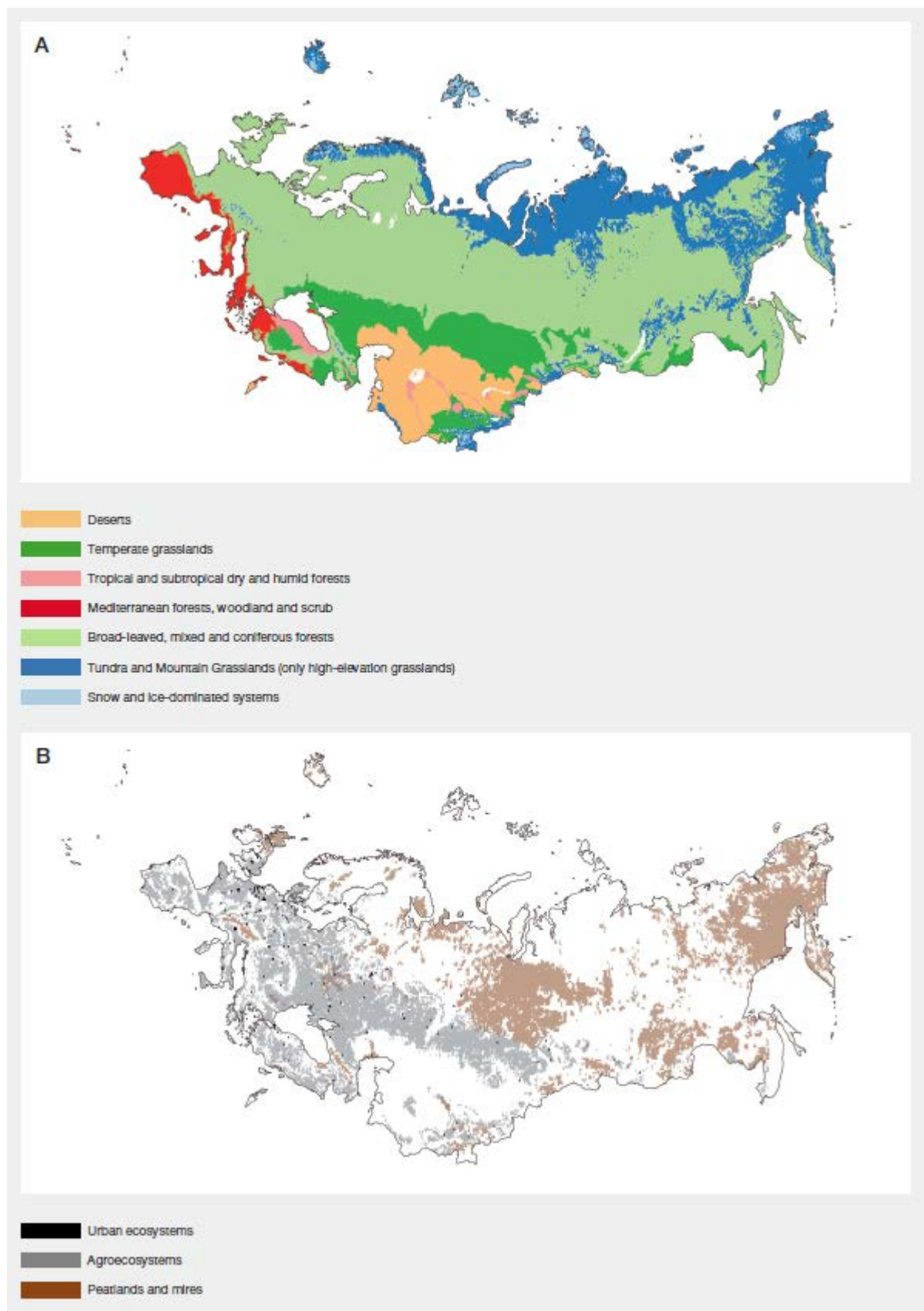
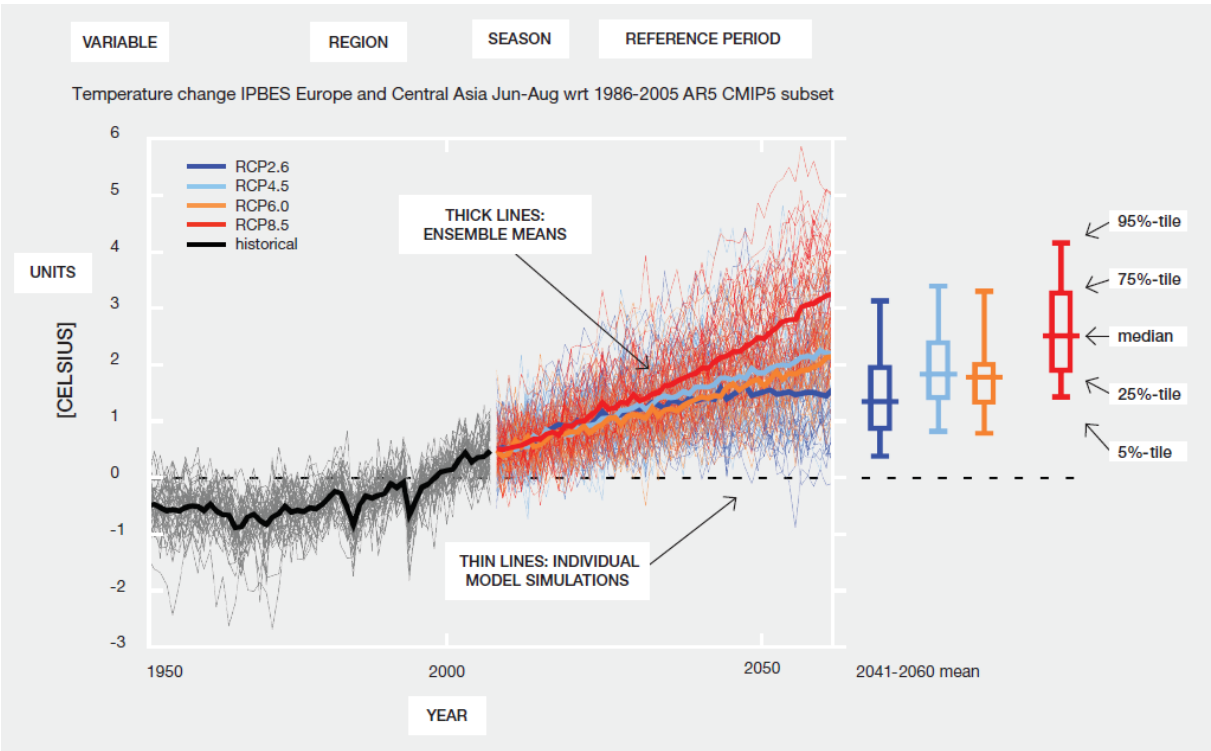


Figure 4.2: Spatial distribution of units of analysis for Europe and Central Asia (A) and additionally important land cover elements (B) for Chapter 4 (see Chapter 1).

17869



17870

17871 **Figure 4.3: Explanation of a typical time series figure used to present projected temperature and**
17872 **precipitation changes for Europe and Central Asia (modified from IPCC (2013b)).**

17873

17874 **4.2.5.2 Indirect drivers**

17875 Various methods were employed to assess indirect drivers. We used a combination of key words in
17876 English and several native languages in the Europe and Central Asia region (such as French, Italian,
17877 Swedish, Albanian, Russian, Ukrainian, Hungarian) to retrieve peer-reviewed articles in Scopus, e-
17878 library and Google Scholar. We also made use of the grey literature published in native languages of
17879 countries from different subregions of Europe and Central Asia. Indigenous and local knowledge and
17880 practices were assessed through analysis of traditional land uses of indigenous peoples and local
17881 communities and their drivers of change.

17882 We applied qualitative systems modelling methods (e.g., Wolstenholme & Coyle, 1983) using causal
17883 loop diagrams to structurally map the dynamic inter-relationships within and between indirect and
17884 direct drivers of change in biodiversity and nature’s contributions to people. Causal loop diagrams
17885 provide a concise format for describing complex interconnected system structures and behavioural
17886 directionality. They use arrows to indicate direct causal relationships between independent and
17887 dependent variables. These relationships can be either in the same direction, represented by a positive
17888 (+) sign, or in the opposing direction, represented by a negative (–) sign. Thus, if independent variable
17889 A connects to dependent variable B by an arrow with a plus (+) sign, the underlying logic of the causal
17890 loop diagram is that an increase (decrease) in A’s behaviour will lead to an increase (decrease) in B’s
17891 behaviour. If the arrow connecting A to B is accompanied by a negative (–) sign then the diagram
17892 indicates that an increase (decrease) in A will lead to a decrease (increase) in B. In some cases, variable
17893 concepts have been amalgamated or broadly aggregated, or otherwise relationships between
17894 independent and dependent variables have been strongly simplified, in such a manner as to impair the
17895 clear directionality of a relationship. In these cases, arrows are not represented by a sign. For example,

several arrows in overview causal loop diagrams do not carry directional signs, as these arrows are aggregates of multiple, variously signed, relationships.

The causal loop diagrams (CLDs) provided in this chapter are intended to convey the major dynamic relationships identified via the literature review process. Each variable and link is thus based on explicit evidence from one, or several, references. Although expert opinion was gathered during a series of workshops to guide an iterative modelling process, no dynamics have been included in the finalized CLDs without substantiation in published materials. No representation of a fully interconnected model of all identified dynamics is provided. Such a model would be too complex, and would defeat the purpose of using CLDs as communicative devices. Rather, we present a set of nested models throughout the chapter, each providing a level of detail regarding identified trends and major driver dynamics. As such, the CLDs unpack the indirect and direct driver boxes of the IPBES conceptual framework into an overview model of indirect and direct driver categories (see **Figure 4.1**). This overview model is then further unpacked at a variety of levels of detail to examine the major dynamics influencing the indirect and direct driver interactions. Indirect and direct driver categories are colour-coded in each of the CLDs according to the legend in **Figure 4.11**. Boxes around variables are used either to signify stocks or to contain a variety of identified sub-variables within an overarching variable. Variables in bold text are used to help guide readers in linking the CLDs with the central themes discussed in respective texts. Grey diamond-shaped boxes around variables are used similarly to aid readers in locating the major trends in land-use change within the diagrams.

4.3 General trends in indirect drivers in Europe and Central Asia

As described in Section 4.1.2, a more specific assessment of indirect drivers in relation to each direct driver is conducted in Sections 4.4-4.8. General trends are assessed in this section.

4.3.1 Institutional drivers

Regulations, including legislation and detailed institutional arrangements, shape all direct drivers and also to some extent all the other indirect drivers. Regulations are the result of purposeful collective political action and reflect the power balance between conflicting interests. Therefore, political and economic conflicts (cultural and economic drivers), influence institutional drivers. Knowledge about the effects of direct drivers on biodiversity and nature's contributions to people increases public awareness and the prices of material contributions from nature and thereby acts as a feedback to institutional drivers (**Figure 4.1**).

In general, the institutional capacity to make and enforce regulations is strong in Western and Central Europe (see Chapter 6). For example, the European Union's Common Fisheries Policy (CFP) illustrates institutional capacity in that regulations have been passed to restore and maintain fish stocks above biomass levels capable of producing maximum sustainable yield, although half of the fish stocks exploited by the fishing fleet of European Union countries are still overexploited (Guillen et al., 2016), see Section 4.4.1.2.

On the other hand, for the European Union's Common Agricultural Policy (CAP) the new environmental prescriptions – including maintaining existing permanent grasslands, crop diversity, and establishing ecological focus areas – maybe “so diluted that they are unlikely to benefit biodiversity” (Pe'er et al., 2014) (Section 4.5.2.2). The most significant recent change in environmental institutional drivers in Europe and Central Asia is arguably the transformation of the energy sector in the European Union.

17939 Here, political leadership, new policies and economic incentives have catalysed technological
 17940 advancements resulting in lower prices for solar and wind power. These lower prices have
 17941 subsequently become economic drivers for decreased pollution and greenhouse gas emissions (Bürer
 17942 & Wüstenhagen, 2009).

17943 For example, the German Renewable Energy Act (EEG) from 2000 has become a major driver for
 17944 transforming the energy sector, increasing generation of renewable energy from 29 TWh in 1999 to
 17945 161 TWh in 2014 (Lauber & Jacobsson, 2016). However, substantial trade-offs may result from a lack
 17946 of mainstreaming. In a scenario for energy crops, (Gutzler et al., 2015) project substantial reduction
 17947 in biodiversity and landscape scenery, and increased soil erosion and need for water protection. These
 17948 three examples from the fishing, agriculture and energy sectors suggest that strong institutional
 17949 capacity is not sufficient to safeguard biodiversity and nature's contributions to people.

17950

17951 4.3.2 Economic drivers

17952 We have identified the material intensity of gross domestic product (GDP), rather than GDP itself, as a
 17953 main economic driver. The relationship between GDP and resource use has long been debated. The
 17954 contributions of many scholars – for instance Carson (2002), Boulding (1966), Georgescu-Roegen
 17955 (1993) – highlighted that serious problems arise from both the quality of the waste (ecotoxicity) and
 17956 the scale of human activities. The amount and the rate at which matter passes through society (the
 17957 material throughput) and becomes waste is a major indirect driver of biodiversity loss. This is also
 17958 called the industrial and socioeconomic metabolism (González de Molina & Toledo, 2014). Despite
 17959 some evidence that prosperity or human wellbeing does not increase further once an average income
 17960 threshold has been reached (Kubiszewski et al., 2013 suggest a threshold as low as 7,000 USD/year
 17961 and person), Governments in countries with much higher per capita GDP strive hard to increase it
 17962 further. A growing body of literature suggests that the challenge is to decouple quality of life (wellbeing
 17963 or prosperity) from environmental degradation and pay less attention to GDP (T. Jackson, 2009;
 17964 Raworth, 2017; Røpke, 2016; van den Bergh, 2010, 2011; Victor, 2008).

17965 Fundamentally, economic growth is largely explained by investments in real capital and there is a near-
 17966 linear relationship between GDP growth and physical capital accumulation in most countries
 17967 (Malmaeus, 2016). There are, in turn, clear correlations between investments in physical capital, and
 17968 resource use including metals (Chen & Graedel, 2015; Kondo, Nakajima, Matsubae, & Nakamura,
 17969 2012), gravel and sand (UNEP, 2014), and biomass.

17970 Growth-oriented policies aim to enhance production and consumption and, except for the economic
 17971 contraction following the financial crisis in 2008, domestic material consumption (DMC) has not
 17972 recently decreased in general in most countries in Western and Central Europe (4.4.4.2) (Eurostat,
 17973 2017b). Target 8.4 of Sustainable Development Goal 8 (“decent work and economic growth”) requires
 17974 governments to “endeavour to decouple economic growth from environmental degradation”.
 17975 However, GDP growth will have a negative effect on ecosystems unless countries succeed in absolute
 17976 decoupling, sufficiently large to achieve the environmentally-oriented Sustainable Development Goals.
 17977 Relative decoupling, where resource use increases, but at a slower pace compared to GDP, is no longer
 17978 an option except for low-income countries (Raworth, 2017).

17979 Decoupling of GDP growth from resource use and environmental impacts is a requirement for
 17980 sustainable growth (Bithas & Kalimeris, 2013; OECD, 2011; van den Bergh, 2010). This can be achieved
 17981 theoretically, but has proved difficult to accomplish empirically. For example, global modelling
 17982 suggests that absolute decoupling, in terms of 50% reductions of CO₂ emissions and resource use,
 17983 would require very strong abatement and resource efficiency policies. Because of economic

17984 adaptations and technological development this would have negligible effects on economic growth
 17985 and employment until 2050 (Schandl et al., 2016). The lack of absolute decoupling has been observed
 17986 empirically (UNEP, 2011). It is often explained by the so-called rebound effect, stating that less demand
 17987 for natural resources arising from increased productivity results in lower prices and therefore higher
 17988 demand for natural resources (Sorrell, 2007).

17989 The most well documented case of economic growth as a driver of environmental impact is between
 17990 GDP growth and CO₂ emissions (e.g. Raftery, Zimmer, Frierson, Startz, & Liu, 2017). Lægreid (2017)
 17991 found a very robust connection between economic growth and larger greenhouse gas emissions,
 17992 hence no absolute decoupling. However, in a study of 131 countries, Szigeti et al. (2017) found absolute
 17993 decoupling between GDP and ecological footprint for 40 countries and relative decoupling for 77
 17994 countries. Although the evidence is inconclusive, there are signs of relative decoupling occurring in
 17995 Europe and Central Asia, and sometimes also absolute decoupling, but this is rarely sufficient to
 17996 achieve climate goals.

17997 The European Union has recently adopted several policies to promote resource efficiency (EEA, 2014e)
 17998 and sustainable growth (European Commission, 2017b). Economic drivers have been altered, for
 17999 example by new legislation and the emission trading system for carbon. However, the challenges of
 18000 decoupling and the rebound effect require more profound changes in economic drivers, especially
 18001 taxes (Font Vivanco, Kemp, & van der Voet, 2016; Polimeni et al., 2012). The tax system is of
 18002 fundamental importance as an institutional and economic driver since it modifies all market prices and
 18003 therefore changes incentives for producers and consumers. Despite proposals for environmental fiscal
 18004 reform (EFR) by UNEP's "Green Economy" (2011) and the United Nations' Strategic Plan for Biodiversity
 18005 2011-2020, little progress is evident in Europe and Central Asia. For example, the total revenue from
 18006 environmental taxes in the EU-28 in 2014 was 2.5 % of gross domestic product (GDP), or 6.3 % of the
 18007 total revenues derived from all taxes and social contributions. These proportions have *decreased* since
 18008 2002, from 2.6 % and 6.8 % respectively (Eurostat, 2017b).

18009 Decoupling is an important issue only if growth in GDP is assumed. This is the case for the European
 18010 Union and its growth strategy Europe 2020, in which economic growth and job creation are top priority
 18011 goals expressed as smart, sustainable and inclusive GDP growth (European Commission, 2017b).
 18012 However, if a more "agnostic" approach to GDP growth is taken, resource efficiency and meeting the
 18013 Sustainable Development Goals can be targeted directly without too much attention to whether GDP
 18014 increases or decreases a few per cent (Raworth, 2017; van den Bergh, 2011). The literature on
 18015 "degrowth" aims at decoupling human wellbeing and quality of life from GDP growth: the prefix smart,
 18016 sustainable and inclusive are kept, but "growth" is replaced by "development" (Martinez-Alier, 2016).

18017 While sustainability transformations would result in growth in sustainable technologies, it would also
 18018 shrink non-sustainable technologies (van den Bergh, 2010, 2011). Targets for GDP growth (or de-
 18019 growth) obfuscate the idea of transformation. For example, sustainable consumption in high-income
 18020 countries is more about reducing the unsustainable aspects of consumption than increasing the more
 18021 sustainable aspects of consumption. Focusing on such transformations or transitions represents
 18022 different policy goals compared to pleas for green or sustainable growth (Geels, McMeekin, Mylan, &
 18023 Southerton, 2015; Lorek & Spangenberg, 2014; Spangenberg, 2014).

18024 Global trade exposes ecosystems as being part of global supply and demand. This impacts interregional
 18025 flows (see 4.2.5) and prevents price signals from responding to local scarcity of natural resources (see
 18026 4.4.1.3). A third aspect of global trade is the institutional competition it entails. National Governments
 18027 are reluctant to internalize external costs from natural resource extraction and pollution because that
 18028 may impede the international competitiveness of taxed corporations (Ayres et al., 2013). Globalized

18029 financial markets, including commodity derivative markets and algorithmic trade, have increasing
18030 impacts on the world's ecosystems (Galaz, Gars, Moberg, Nykvist, & Repinski, 2015).

18031

18032 4.3.3 Demographic drivers

18033 Europe and Central Asia is home to approximately 910 million people or 14.5% of the total world
18034 population (United Nations, 2015), almost half of whom live in Western Europe (**Table 4.4**). Although
18035 the population in the region is projected to be stable until 2050, there are important differences within
18036 subregions. For example, the population growth rate of Turkey is 1.69% and, without Turkey, the rate
18037 of population decline in Central Europe is much greater (-0.25%) than illustrated in **Table 4.4** (-0.14%).
18038 The population decline projected for 2015-2050 in Central and Eastern Europe due to low birth rates,
18039 coupled with emigration and moderate mortality due to low life expectancy, is unprecedented in
18040 recent history (W Lutz, 2010). Because human populations are increasing in Central Asia and Turkey
18041 and decreasing in Central and non-Caucasus Eastern Europe, it is likely that a high potential for
18042 migration from Turkey and Central Asia to Central and Eastern Europe will develop until 2050 (W Lutz,
18043 2010). Armed conflicts have profound effects on migration, for example, Turkey recently received (by
18044 March 2016) over 3 million refugees from Syria, Iraq and Afghanistan (UNHCR, 2017).

18045 **Table 4.4: Population trends in Europe and Central Asia (United Nations, 2015) (ECA – Europe and**
18046 **Central Asia, WE – Western Europe, CE – Central Europe, EE – Eastern Europe, CA – Central Asia)**

	ECA	WE	CE	(Turkey)	EE	CA
Population 2015 (million)	910	423	202	(79)	218	67
Fertility rate (children/woman)	-	1.71	1.54	-	1.67	2.83
Net migration (per 1,000 inhab.)	-	2.98	-1.35	-	-1.55	-1.47
Population growth/year (%)	-	0.39	-0.14	(1.69)	0.02	1.65
Population 2050 (million)	913	441	192	(88)	192	88

18047

18048 The age distribution of the population is also changing. With improvements in health care, life
18049 expectancy is increasing in each subregion and their populations are aging, meaning a higher
18050 proportion of older age groups (Wolfgang Lutz, Sanderson, & Scherbov, 2008). This has several
18051 consequences for biodiversity and nature's contributions to people. First, total consumption may
18052 further increase as the consumption of energy, food, medicine and others by elderly people increases
18053 even if population size decreases. Ecological footprints may therefore increase even in subregions
18054 currently showing human population declines (Hossman et al., 2008). Second, aging in rural areas will
18055 lead to a decrease in the number, capacity and effectiveness of the rural workforce, which will
18056 ultimately create the socio-economic conditions for intensified use of natural resources (mainly by
18057 agriculture, forestry, or fishery) by large corporations rather than by private farmers (Gentile, 2005).
18058 Third, age profile also strongly influences where people choose to live, which affects urban growth
18059 patterns and subsequent impacts on biodiversity and nature's contributions to people (Fontaine et al.,
18060 2014).

18061 Fast population growth in Central Asia, with further expected increase in urbanization, will present
18062 risks to the already overpopulated lowland and riparian areas of the subregion and will influence
18063 biodiversity and ecosystem services (Osepashvili, 2006). Human population growth will take a heavy
18064 toll on water use. This is likely to result in a decline in water-related services, which may trigger water
18065 conflicts (e.g. in Fergana valley in Uzbekistan, Tadjikistan and Kirgizistan) or water-use regulations. In

18066 other areas, the collapse of irrigation-based agriculture due to water shortages may cause
 18067 desertification, such as the complete drying up of the Aral Sea (Gentile, 2005).

18068

18069 4.3.4 Cultural and religious drivers

18070 In democratic societies, public awareness and knowledge of environmental change are the underlying
 18071 drivers for both institutional change and consumer demand (Nolan & Schultz, 2015). Hence, the
 18072 feedback to indirect drivers often starts with the cultural driver that we call “public awareness”. The
 18073 cultural belief that further GDP growth will facilitate sustainable development is deeply rooted in
 18074 Europe and Central Asia, calling for smart, inclusive and sustainable growth (European Commission,
 18075 2010). In recent years, many studies have shown that, if biodiversity and nature’s contributions to
 18076 people are to be used sustainably, growing anthropogenic pressures paralleled by environmental
 18077 degradation would require a radical change in our political value system, with a reorientation of
 18078 fundamental policy goals from GDP growth towards well-being, environmental quality, employment
 18079 and equity (Hardt & O’Neill, 2017; T. Jackson, 2009; Kallis, Kerschner, & Martinez-Alier, 2012; Martínez-
 18080 Alier, Pascual, Vivien, & Zaccai, 2010; Røpke, 2016; Victor, 2008).

18081 All regional cultures are increasingly becoming part of a global cultural process. With increasing access
 18082 to media, information and exchange among regions, the cultural changes taking place in Europe and
 18083 Central Asia form part of the general globalization trend. Although distinct local cultures, with their
 18084 beliefs and specific relation to nature may well persist, they will do so in parallel to global cultural
 18085 trends (Harari, 2014). Cultural and religious beliefs are often exploited politically, which has been
 18086 evident in the region in recent years. However, it is not clear how these changing beliefs and opinions
 18087 affect biodiversity and nature’s contributions to people.

18088 Central to the effect on biodiversity is how cultural identity and religious beliefs influence lifestyles in
 18089 terms of consumption patterns. Values promoting a vegetarian diet are, for example, likely to reduce
 18090 the land-use area needed to produce food, and thus the impacts on nature Alexander et al. (2016).

18091 Heterogeneous agricultural landscapes provide biodiversity and are therefore supported by agri-
 18092 environmental schemes in the European Union. An increasing focus on recreation and eco-tourism in
 18093 Western Europe has become a further justification for, and therefore driver of, political and economic
 18094 support to heterogeneous landscapes (Thomas Hahn, Heinrup, & Lindborg, 2017); (Beilin et al., 2014;
 18095 Navarro & Pereira, 2012). Beyond eco-tourism, the increasing popularity of spiritual refreshment and
 18096 other spiritual experiences have considerable potential for the recognition of nature’s contribution to
 18097 people.

18098

18099 4.3.5 Scientific and technological drivers

18100 If population is constant and affluence, measured in GDP per capita, is increasing, the equation $I =$
 18101 $P \cdot A \cdot T$ (Impact = population * affluence * technology) suggests very high expectations of technology
 18102 to ensure sustainable growth. However, technological innovation is not a driver, which in itself ensures
 18103 lower negative environmental impact. Scientific and technological innovation is a double-edged sword
 18104 (Westley et al., 2011), which could have positive or negative effects on biodiversity. As mentioned in
 18105 Section 4.2.2, innovation is not a neutral process driven mainly by the curiosity of researchers and
 18106 innovators. The general pattern of world market prices of natural resources is a sharp decline during
 18107 the past fifty to one hundred years. At the same time the price for labour has increased dramatically,
 18108 augmented by the tax system (Eurostat, 2017b). Technological innovation has therefore not targeted
 18109 resource efficiency, but instead labour productivity (Lorek & Spangenberg, 2014).

Energy and resource efficiency have become political targets. The literature suggests a very high potential for, for example, energy supply and storage, green information technology transportation, foodstuffs, agricultural engineering, design strategies, lightweight construction, as well as the concept “using instead of owning” (Rohn, Pastewski, Lettenmeier, Wiesen, & Biengen, 2014). Realising this potential requires support from institutional and economic drivers (Ayres et al., 2013), and ultimately cultural-religious drivers. For example, if cultural beliefs support “modern” high-input agriculture and if new European Union member States in the Baltic Sea drainage area adopt the same use of fertilizers as Denmark, Sweden and Finland, the eutrophication of the Baltic Sea will accelerate (Larsson & Granstedt, 2010). If the Baltic countries want to achieve the Baltic Sea Action Plan, then climate smart and “Baltic Sea smart” technologies and farm systems are needed.

4.4 Drivers of natural resource extraction and its effects on biodiversity and nature’s contributions to people

This category of driver is often called “overexploitation,” focusing on overfishing (MA, 2005b). As mentioned before we have chosen a more neutral term, extraction. This section assesses two biotic forms of natural resource extraction: fishing and hunting; and two abiotic forms: mineral and fossil fuel extraction, and water use and desalination. Agriculture, forestry (logging) and traditional land use (gathering wild plants, berries and mushrooms) are assessed under land-use change.

Natural resource extraction is, according to a synthesis based on the IUCN Red List data, “by far the biggest driver of biodiversity decline” (Maxwell et al., 2016a). However, that conclusion only holds if unsustainable logging is included. Still, hunting, fishing and mining together pose a considerable threat to biodiversity (Maxwell, Fuller, Brooks, & Watson, 2016b).

4.4.1 Fishing

4.4.1.1 Effects of fishing on biodiversity and nature’s contributions to people

Fishing affects 1,118 of the 8,688 assessed red list species (Maxwell et al., 2016a). Both marine and inland fish stocks in Europe and Central Asia have declined over recent decades. Trawling is a fishing technology with adverse effects on biodiversity, through habitat destruction. Over recent decades, trawlers have become dominant among fishing boats, especially vessels greater than 100 gross registered tons (Anticamara, Watson, Gelchu, & Pauly, 2011). Despite regulations, half of the fish stocks exploited by the fishing fleet of the European Union are still overexploited (Guillen et al., 2016). Overfishing affects genetic diversity and the age structure of the targeted fish population. Furthermore, removal of top predators through overfishing may disrupt ecological relationships, food webs structure and energy flow pathways (García-Charton et al., 2008; A. Pérez-Ruzafa, García-Charton, Barcala, & Marcos, 2006; Angel Pérez-Ruzafa et al., 2008).

Inland waters have received less attention than global fisheries. One of the symptoms of intense overfishing in inland waters is the collapse of particular stocks. Such collapses constitute a biodiversity crisis rather than a fisheries crisis. However, intensive fishing frequently acts synergistically with other pressures, and its consequences for inland fisheries and ecosystems are poorly understood and documented (J. D. Allan et al., 2005).

Nevertheless, more stocks are recovering, and the combined effects of climate warming and reduced fishing mortalities have resulted in record large stocks of e.g. mackerel in the Norwegian Sea, plaice in

the North Sea and cod in the Barents Sea. The recovery of these major stocks now impacts other parts of the ecosystems through both predation and competition. For instance, a recent collapse in the capelin stock in the Barents Sea was likely partially due to cod predation and competition with cod likely impacts the condition of marine mammals (Bogstad, Gjørseter, Haug, & Lindstrøm, 2015).

4.4.1.2 Trends in fishing

The marine area under the jurisdiction of European Union member States is substantial — larger than the total land area of the European Union— and supports industries such as shipping, fishing, offshore wind energy, tourism, and oil, gas and mineral extraction (EEA, 2012b). Fishing effort has increased over recent decades in Western Europe and Central Europe. However, some analyses suggest a stagnating or even decreasing trend in fishing effort in European marine waters (Gascuel et al., 2016). Fishing effort is a combination of fleet capacity (number of vessels or engine power) and the amount of time spent at sea. Reduced fishing effort may however be counteracted by an increase in the efficiency in detecting and catching fish.

Despite recent attempts by the fishing sector to ensure sustainable practices and recovery of fish stocks, the industry is still characterized by overfishing and declining volumes of fish catch (EEA, 2012b). During recent decades, aquaculture production has been increasing. However, some aquaculture species, like salmon and tuna, are carnivores that feed on other fish that are, themselves, overfished (Naylor et al., 2000; Pauly et al., 2002). Demand for fish in the European Union continues to exceed the sustainable yield and a significant proportion of the fish consumed in the European Union is imported from, for example, Norway, China, Morocco, and the USA (Figure 4.4).

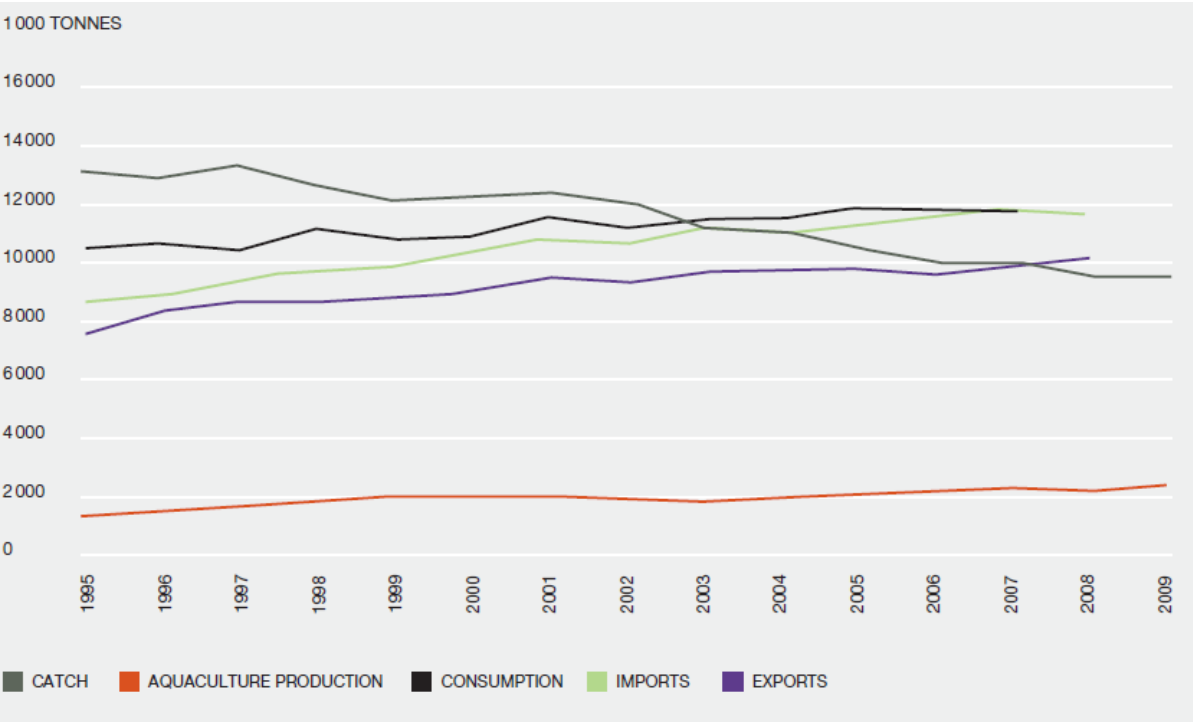


Figure 4.4: Total fish catches, aquaculture production, consumption, imports and exports for European Environmental Agency (EEA)-33 countries (except Liechtenstein) and the western Balkans, 1995 to 2009.³⁶ Consumption refers only to human consumption (EEA, 2012d).

³⁶ The EEA currently has 33 member countries and six cooperating Balkan countries. The 33 member countries include the 28 European Union member States together with Iceland, Liechtenstein, Norway, Switzerland and Turkey. The six West Balkan

4.4.1.3 Drivers of fishing

The drivers of fishing are summarized in **Figure 4.5**. Overcapacity accompanied by non-compliance (illegal, unregulated and unreported fishing) are the most common immediate causes for overfishing (Boonstra & Österblom, 2014). Knudsen et al. (2010) identify eight main drivers of overfishing, most of them economic in nature. Fishing costs (including operational costs and fuel prices) and incomes (including fish prices and demand) are important drivers. Fishing costs increase when stocks become over-exploited, but the subsequent increase in fish price motivates investments and continued fishing. Furthermore, tax exemptions and government subsidies, especially for fuel, are very important drivers to offset the increased costs and to maintain a high fishing capacity (**Figure 4.5**). Despite changes in fishing policies, Western Europe pays about six billion US dollars annually (of which four billion by the European Union and almost two billion by Russia) in capacity-enhancing (“harmful”) fishing subsidies, which is the second most after Asia (Sumaila, Lam, Le Manach, Swartz, & Pauly, 2016).

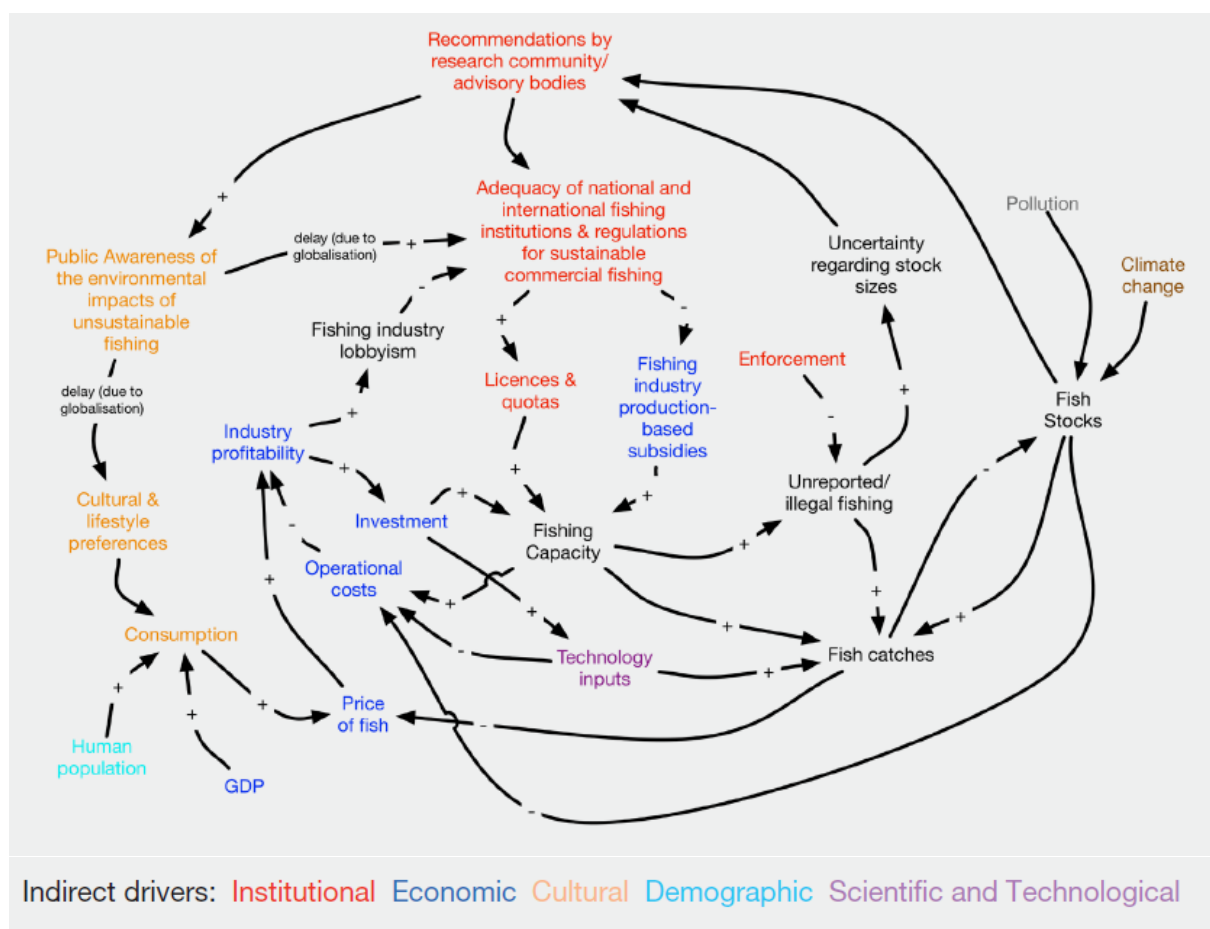


Figure 4.5: Causal loop diagram of fishing, illustrating causes of the present situation of overfishing. See text for further clarification.

The adoption of new technologies leading to overcapacity in vessels and engines is also a major driver for increased fishing (Knudsen et al., 2010; Österblom et al., 2011). Human population growth, associated demand for fisheries products, and multiple effects of pollution, coastal degradation and climate change are other important factors in the analysis of trends in fisheries (Garcia & Rosenberg,

countries are cooperating countries: Albania, Bosnia and Herzegovina, the former Yugoslav Republic of Macedonia, Montenegro, Serbia as well as Kosovo.

2010). Small changes in temperature affect distribution and abundance of fishes, but can be positive or negative for local fisheries depending on the species and regions (Pörtner & Peck, 2010; Roessig, Woodley, Cech, & Hansen, 2004).

For the majority of the stocks, political decision-makers have not followed recent scientific advice, for example from the International Council for the Exploration of the Sea (ICES) and the Mediterranean Advisory Council (MEDAC), and have set Total Allowable Catch (TAC) to levels higher than the scientific recommendation (Voss et al., 2017). Institutional drivers are beginning to change, thanks to information and recommendations from universities, consultative councils and international organizations, with a resulting increase in public awareness. This in turn drives both the market, by avoiding red listed fish, and the political system to regulate fishing and enforce illegal fishing (**Figure 4.5**). For example, the European Union's 2014 update of The Common Fisheries Policy (CFP) illustrates institutional capacity in that regulations have been passed for restoring and maintaining fish stocks above levels capable of producing maximum sustainable yield. However, half of the fish stocks exploited by the European Union fishing fleet are still overexploited (Guillen et al., 2016).

Resource users who are limited to local resources have an incentive to sustain these resources because they do not have a substitute, while users who can access global resources have no such incentives. Therefore, good stewardship depends on institutions where users are held accountable for sustaining the local resources (Berkes et al., 2006). Consumers and citizens are not reached by the feedbacks of natural resource depletion such as price signals and physical scarcity. Three reasons why price fails to provide an accurate signal of declining fish stocks to globally distributed consumers have been proposed by Crona et al. (2016). First, the costs of depleting the resource through habitat damage by trawling and by-catch of endangered megafauna have little effect on yield or revenue, as these costs are not reflected in the market price. Second, better fishing technologies can maintain or even increase harvest levels despite declining fish stocks. Third, when declining stocks are substituted by global trade from other regions, market signals to consumers also fail. All of these factors result in “masking” and “dilution” of the feedbacks to consumers and citizens by preventing increases in prices and hence in awareness (economic and cultural drivers), thereby reducing public pressure for institutional responses (Morato, Watson, Pitcher, & Pauly, 2006).

4.4.2 Hunting

4.4.2.1 *Effects of hunting on biodiversity and nature's contributions to people*

Hunting is practiced across a wide spectrum of cultural, institutional, economic and environmental contexts within Europe and Central Asia. Whilst hunting clearly impacts the populations of the hunted species, the effects on biodiversity and nature's contributions to people vary. Hunting takes several forms and is done for various reasons, including management, subsistence, and recreation (A. Fischer et al., 2013). Under “management hunting” the population densities of certain large-bodied game species are controlled by hunters with potentially positive impacts on biodiversity and forestry (Brainerd, 2007). On the other hand, these game species are sometimes kept at high densities for recreational hunting purposes, resulting in overgrazing, over-browsing and trampling of forest ecosystems by large herbivores, leading to reduced diversity of the understory vegetation and stunted or no regrowth of forest trees and understory plants. Browsing and grazing by wild ungulate game species (such as several deer species or wild boar) are a significant cause of plant species loss regardless of the type of forest management (Pollock, Milner, Waterhouse, Holland, & Legg, 2005; Schulze et al., 2014). Beyond the direct mortality impact on hunted animals, therefore, altered vegetation dynamics can also change animal communities, and the current high densities of ungulate populations in

Germany, and Romania and other Central and Eastern European countries, are a major threat to the biodiversity of deciduous forests (Schulze et al., 2014). Hence, the hunting sector and its management is also a main driver of forest change.

Management hunting also provides material (meat) and non-material contributions to people, for example by maintaining traditions and promoting social relations (A. Fischer et al., 2013). This is also the focus in indigenous or subsistence hunting where cultural identity is emphasized. However, there are signs that indigenous or subsistence hunting is declining, for example in traditional communities in Faroe Islands due to the changing cultural values of younger generations (Nieminen, Roto, & Syrjämäki, 2004).

Sport and trophy hunting are not motivated by ecological objectives (if so, we would call it management hunting). Sport hunting, including the trapping of individuals, has been mostly aimed at large game species in Europe and Central Asia. These include predatory mammals such as bears, wolves and lynx; herbivorous mammals such as red deer, moose, elk, ibex and chamois; omnivorous mammals such as wild boar; and birds (mainly ducks, geese, waders, doves and several passerines). This has resulted in the extinction of, for example, Caucasian moose and wisent, Carpathian wisent, and ibex on the Iberian Peninsula. The hunting, trapping and poaching of migratory birds is a chronic conservation problem, particularly in the Mediterranean countries, where birds, even small passerines, have been traditionally hunted and trapped for human consumption or for sport (Vickery et al., 2014).

4.4.2.2 Trends in hunting

In the European Union, the Birds Directive currently allows the hunting of 82 species (25 ducks and geese, 15 gallinaceous species, 22 waders, shorebirds and gulls, five doves, 12 passerine species and three rallied species) of which 24 can be hunted in all member States (Annex II of Birds Directive). Many species that are declining at an alarming rate, may still be hunted in several European countries (for example skylark, lapwing, curlew, black-tailed godwit, garganey, taiga bean goose, pintail, snipe, quail and turtle Dove). In addition to hunting, selective trapping is allowed in several European Union member States (Art. 9 of Birds Directive), where net traps and cage traps lead to the killing of tens of thousands of skylarks, Ortolan buntings, golden plovers, turtle doves, quail and lapwings in France, and millions of thrushes in Malta, Spain (Catalonia) and Italy annually (Fenech, 1992; Hirschfeld & Heyd, 2005).

Since the 1950s there has been a general decrease in the size of the annual wild bird hunting bag (total catch) in Western Europe. Hunting pressure is still high, although uncertain in the south and east of the region (Weinbaum, Brashares, Golden, & Getz, 2013). In 2005, the total hunting bag in the EU-27 was around 102 million individuals of 82 bird species (Hirschfeld & Heyd, 2005). Hunting bag data also suggest a recent short-term increase in hunting pressure for mammals. For instance, the hunting of red deer (*Cervus elaphus*) has increased exponentially in eight of 11 Western and Central European countries studied (Milner et al., 2006).

4.4.2.3 Drivers of hunting

The culture of hunting is based on a value system that is deeply rooted in traditions in Europe and Central Asia. However, traditions emerging from subsistence hunting are today based on identity and life-style, expressed as sport and trophy hunting or management hunting, with wild meat as a bonus (A. Fischer et al., 2013). Demographic drivers like urbanization do not seem to change these cultural drivers; there is still a high density of hunters per km², 50 in Cyprus, followed by 47 in Malta, 5.0 in

18287 Ireland, 3.8 in Denmark, 3.3 in the UK, 2.5 in Italy and Portugal, 2.4 in France, and 2.0 in Greece
 18288 (Hirschfeld & Heyd, 2005). Illegal hunting and trapping is still common in the south and east of the
 18289 Europe and Central Asia region (Arizaga & Laso, 2015; Michel, 2008).

18290 Hunting is well regulated in most countries in Europe and Central Asia, however, law enforcement is
 18291 lagging behind in many Central Asian countries and the southern parts of Western and Central Europe
 18292 (Michel, 2008). Hunter associations are powerful interest groups in many countries and the
 18293 governance trend is to foster stewardship and sustainable management hunting for vulnerable species
 18294 rather than imposing hunting bans (Ministry of Agriculture Nature and Food Quality of the Netherlands
 18295 & Directorate General for the Environment of the European Commission, 2004). Tensions between
 18296 hunters and anti-hunting groups have escalated, e.g. in Malta, with rural surveillance systems and local
 18297 raids by anti-hunting groups, physical fights between anti-hunting activists and hunters or poachers,
 18298 use of drones for observations, and police or army interventions (Veríssimo & Campbell, 2015).

18299

18300 4.4.3 Water use and desalination

18301 4.4.3.1 *Effects on water use and desalination on biodiversity and nature's contributions to people*

18302 Water is extracted from streams, rivers, lakes and wetlands for drinking and bathing, irrigation for
 18303 agriculture, cooling for energy production (power plants), as coolant or reagent in various industries
 18304 and as a leaching agent in mining. Freshwater ecosystems host disproportionately high numbers of
 18305 species relative to their surface area, yet their biodiversity is declining faster than either terrestrial or
 18306 marine biodiversity (Dudgeon et al., 2006; Strayer & Dudgeon, 2010; World Wildlife Fund, 2008). In
 18307 addition, ecosystem services provided by freshwater systems (streams, rivers, lakes, wetlands) were
 18308 estimated to contribute to 20% of the value of all ecosystem services (Costanza et al., 1997).

18309 Groundwater overexploitation, often due to irrigation, results in lowering the groundwater table,
 18310 which increases the risk of desertification. In addition, the chemical composition of groundwater is
 18311 often suboptimal for irrigation due to its high salt/mineral or metal content and irrigation with
 18312 groundwater often leads to salinization or alkalization of the soils. This is a problem in Estonia, Latvia,
 18313 Poland, Hungary, Romania, Moldova and Spain (EEA, 2007) and in many areas of Eastern Europe and
 18314 Central Asia. The intrusion of salt water from the sea in the place of groundwater is an acute problem
 18315 in coastal areas of Denmark, and in coastal Mediterranean areas of Spain, Italy and Turkey, mostly due
 18316 to the water needs of mass tourism facilities and irrigation (EEA, 2007).

18317 Desalination of seawater is increasing to satisfy demand for water due to the present water shortage,
 18318 mainly in semiarid and arid coastal regions (Llamas, Custodio, de la Hera, & Fornés, 2015). It has a long
 18319 history in the Middle East and Mediterranean (Einav & Lokiec, 2003; D. A. Roberts, Johnston, & Knott,
 18320 2010), but studies on the impacts of desalinization on biodiversity are recent and still scarce. The
 18321 greatest environmental and ecological impacts have occurred around older multi-stage flash plants
 18322 discharging salt into water bodies with little flushing. Effects include substantial increases in salinity
 18323 and temperature and the accumulation of metals, hydrocarbons and toxic anti-fouling compounds in
 18324 receiving waters (Al-Taani et al., 2014; Höpner & Lattemann, 2003; D. A. Roberts et al., 2010) and
 18325 sediments (Alharbi et al., 2012)

18326 Effects on ecosystems range from no significant impacts on benthic communities, to reduced leaf
 18327 growth and higher incidence of leaf necrosis, drop in photosynthetic performance and mortality in
 18328 seagrasses, and widespread alterations to community structure in seagrass, coral reef and soft-
 18329 sediment ecosystems when discharges are released to poorly flushed environments (Del-Pilar-Ruso et

al., 2015; Del-Pilar-Ruso, De-la-Ossa-Carretero, Giménez-Casaldueiro, & Sánchez-Lizaso, 2008; Pagès, Pérez, & Romero, 2010; D. A. Roberts et al., 2010).

4.4.3.2 Trends in water use and desalination

Water management has become one of the main concerns for humanity, also in areas where water has until now been considered an unlimited resource. The availability of freshwater resources in a country is determined by geology, climate, land use and external (transboundary) water flows. In Western and Central Europe, the largest freshwater resources are in Norway, Turkey, Germany, France and Sweden (Eurostat, 2015). Many countries receive the majority of freshwater resources externally, with Serbia, Hungary, the Netherlands, Slovakia and Bulgaria receiving over 80% of their freshwater from upstream areas in other countries. The amount of potable freshwater per inhabitant is highest in Iceland, Norway, Serbia, Croatia and Finland, whereas low levels (<3,000 m³ per inhabitant per year) are found in Denmark, Romania, Belgium, the Czech Republic, Cyprus and Malta, and in countries with large human populations (France, UK, Spain, Germany, Italy and Poland) (Eurostat, 2015). In 2012, total water extraction from surface waters was highest in Turkey, Spain, Germany and France (over 24 billion m³ from surface waters, over 5 billion m³ from groundwater) (Eurostat, 2015). Between 2003 and 2013, the amount of freshwater extracted increased most in Malta (43%, mostly groundwater), Slovenia (36%, mostly surface water) and decreased the most in Lithuania (80%, mostly surface water) and Slovakia (39%, mostly surface water) (Eurostat, 2015).

Around 63% of desalinated water worldwide is used for satisfying urban demand for drinking water, 26% for industrial uses, and 6% in power stations for electricity generation (Ziolkowska & Ziolkowski, 2016). The cost of desalinated water is decreasing, thanks to technological and efficiency improvements of the membrane filters, which reduces energy demand (Semiat, 2000; Ziolkowska & Ziolkowski, 2016).

4.4.3.3 Drivers of water use and desalination

Water regulations are cornerstones of national environmental regulations. The rapid decrease in water use in Lithuania and Slovakia mentioned above is mainly a result of institutional drivers (regulations and a better price system). Other important Institutional drivers are regulations and investments in, or subsidies for, wastewater and desalination (“recycling” in **Figure 4.7**). Depletion (unsustainable use) of ground and surface water is driven by high domestic material consumption (DMC) fuelled by urbanization and GDP growth.

Similarly, seawater desalination is driven by growth in human population, income and domestic material consumption in general and growth and urban development, agriculture and tourism in particular (EEA, 2007; Gladstone, Curley, & Shokri, 2013).

4.4.4 Mineral and fossil fuel extraction

4.4.4.1 Effects on biodiversity and nature’s contributions to people

The minerals industry is divided into four sectors: fossil fuels (e.g. coal and oil), metallic minerals (e.g. iron, copper and zinc), construction minerals (e.g. natural stone, sediments and other aggregates, gravel) and industrial minerals (e.g. borates, talc, silica and limestone).

In Western and Central Europe, extraction of abiotic resources is highly dominated by construction and industrial minerals, and to a more limited extent fossil energy (Bahn-Walkowiak, Bleischwitz, Distelkamp, & Meyer, 2012). Dredging and pumping operations have a direct effect on the local biological communities and cause changes in the composition of fauna (A. Pérez-Ruzafa et al., 2007), and reduction in species diversity, abundance, and biomass (Bolam, McIlwaine, & Garcia, 2015; G. Sutton et al., 2009). This changes food webs, particularly lower trophic levels including detritivores, with impacts on carbon cycling (Tecchio et al., 2016).

In Central Asia the extraction and processing of minerals, including poor governance practices and economic pressures (Honkonen, 2013), leads to various environmental impacts including depletion of non-renewable resources and consequent disturbance of the landscape, biodiversity and nature's associated contributions to people (Azapagic, 2004; Старикова, 2014), particularly in vulnerable arid and mountainous territories (Лукашов & Акпамбетова, 2012).

The environmental effects of the mining and minerals industry include gas emissions, discharge of liquid effluents (including acidification of waterways) and generation of large volumes of solid waste, as well as direct destruction or disturbance of natural habitats. Additionally, contamination of water can continue when mining or mineral extraction activity ceases due to acid mine drainage and other toxic leachates. Large water bodies and land are being polluted by natural resource extraction in Central Asia (Жакупов, 2013; Кальменова, 2014) and methane leaks from gas infrastructure and coal mines pollute soil and the Caspian Sea (Dahl & Kuralbayeva, 2001; Каренов, 2006; Муканова [Mukanova, 2015]. Oil production in the Caspian Sea has had a direct impact on ecosystem functioning through pollution (Netalieva, Wesseler, & Heijman, 2005). An increase in the rate of glacier melting has been observed as a consequence of dumping of mine spoil on receding and thinning glacier snouts in Kyrgyzstan (Evans et al., 2015; Jamieson et al., 2015; Kronenberg, 2014). Uranium mining sites pose a threat to biodiversity exposed to high radiation doses (Oughton, Strømman, & Salbu, 2013; Бекболотова & Тойчубекова, 2014; Жолболдиев, 2016; Карсенов, 2011).

4.4.4.2 Trends in mineral and fossil fuel extraction

Fossil fuels and rare earth minerals are the largest contributors to GDP of Central Asia and in the last decade the volume of coal mining has doubled in this subregion (Кабирова, 2009; Плакиткина, 2014). The mineral extraction industry in Central Asia has been driven by trade liberalization and increasing world market prices. The largest share of foreign direct investment in Central Asia is in the natural resource extraction industry. Central Asian Governments seek foreign direct investments as a way to boost local incomes while the high environmental risks and lack of transparent governance have had little effect on economic development (Dikkaya & Keles, 2006; Doroshenko, Shelomentsev, Sirotkina, & Khusainov, 2014).

Since the 1950s most metallic mineral resources have been imported into Western and Central Europe (Calvo, Mudd, Valero, & Valero, 2016; Schaffartzik, Mayer, Eisenmenger, & Krausmann, 2016; Schoer et al., 2012). However, while domestic extraction of metallic mineral has been reduced, extraction of sediments is increasing mainly in coastal areas. Domestic material consumption (DMC) is defined as the annual quantity of raw materials extracted from the domestic territory, plus all physical imports minus all physical exports. It has increased since 1970 (**Figure 4.6**) but decreased from 7.7 to 6.7 billion tonnes in the period 2000-2016 in EU-28. Greece, Spain and Italy almost halved their domestic material consumption since the financial crisis in 2008 and without these countries the domestic material consumption in the European Union has been stable since 2000 (Eurostat, 2017a). Recently there has been an increase in prospecting for resources in previously unexploited and fragile environments such

as the Arctic and on the ocean floor, which consequently increases the pressure on ecosystem resilience in sensitive environments (Martin et al., 2012).

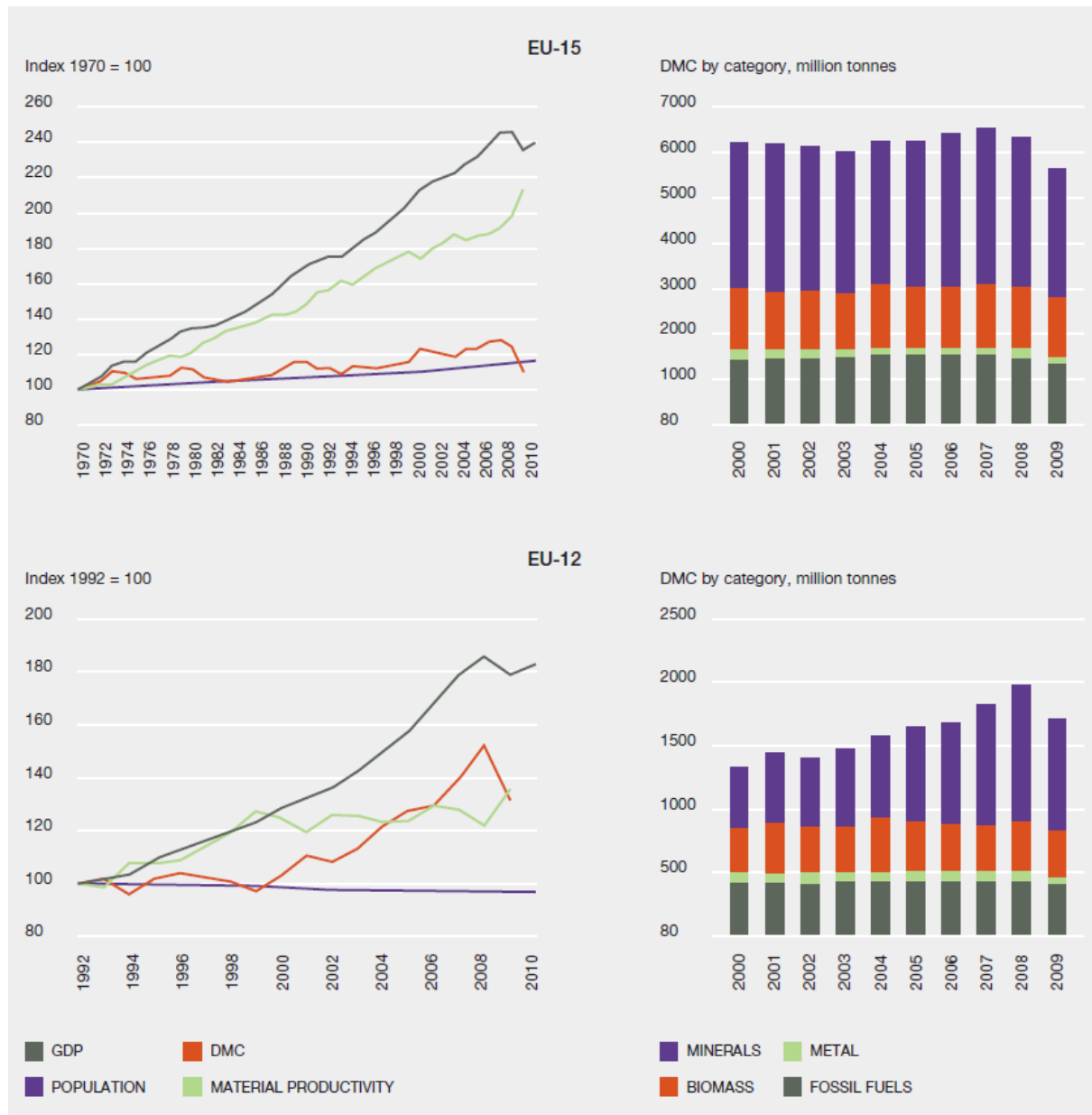


Figure 4.6: Domestic material consumption (DMC) in EU-12 and EU-15 has increased historically except as a result of the financial crisis in 2008 (Martin et al., 2012).

4.4.4.3 Drivers of mineral and fossil fuel extraction

The European Union is aiming to become a resource-efficient, green and competitive low-carbon economy through absolute decoupling of economic growth and environmental degradation (EEA, 2014e). Recent changes in indirect drivers include climate and energy policies, natural resource taxation, subsidies to recycling schemes (Söderholm, 2011) and regulating producers' responsibility for the waste (Ekvall, Hirschnitz-Garbbers, Eboli, & Śniegocki, 2016). This has resulted in reduced use of fossil fuels for energy production, improved energy efficiency and increased resource efficiency. However, domestic material consumption is only beginning to decline from a very high level and the

increases in environmental taxes have only kept pace with other taxes and the GDP, hence the environmental tax reforms called for by the Green Economy (UNEP, 2011) and Convention on Biological Diversity (Aichi Biodiversity Targets) have not progressed since 2002 (Section 4.3.2). On the contrary, some aspects of public support to mineral extraction can be seen as harmful subsidies. In 2010, the metal mining sector in Sweden received subsidies of € 40 million compared to only € 0.6 million for the metal recycling sector (N. Johansson, Krook, & Eklund, 2014). Furthermore, mining companies only pay 0.2% of the revenues from mining as resource tax (Koh, Hahn, & Ituarte-Lima, 2017).

Conversely, in Central Asia, economic growth is currently closely associated with mineral and fossil fuel extraction (Ондаш, 2011), which is anticipated to continue in the future (Doroshenko et al., 2014). Central Asia has initiated policies for increased resource efficiency, mainly targeted at energy efficiency (Ministry of Energy and Industry of the Kyrgyz Republic, 2014; Pomfret, 2010, 2011). However, global initiatives (e.g. the Extractive Industries Transparency Initiative) have so far had a limited effect on sustainable use of natural resources (Furstenberg, 2015).

4.4.5 Drivers of natural resource extraction

Drivers of natural resource extraction are indirect drivers of biodiversity change, as synthesized in **Figure 4.7**. Natural resource extraction basically follows increases in GDP and human population growth (Peet & Hartwick, 2015). Urban sprawl increases this pressure (Schewenius, McPhearson, & Elmqvist, 2014). GDP growth is still the goal of the European Union, but recently the goal has been reformulated toward smart, sustainable and inclusive growth (European Commission, 2017a).

The ecological footprint is an area-based measure of material consumption driving natural resource extraction. Western and Central Europe's ecological footprint is twice the size of its area and consumption patterns remain very high by global standards (EEA, 2014a). Due to institutional drivers, increasing productivity and the financial crisis of 2008, Western and Central Europe's domestic material consumption has decreased recently (4.4.4).

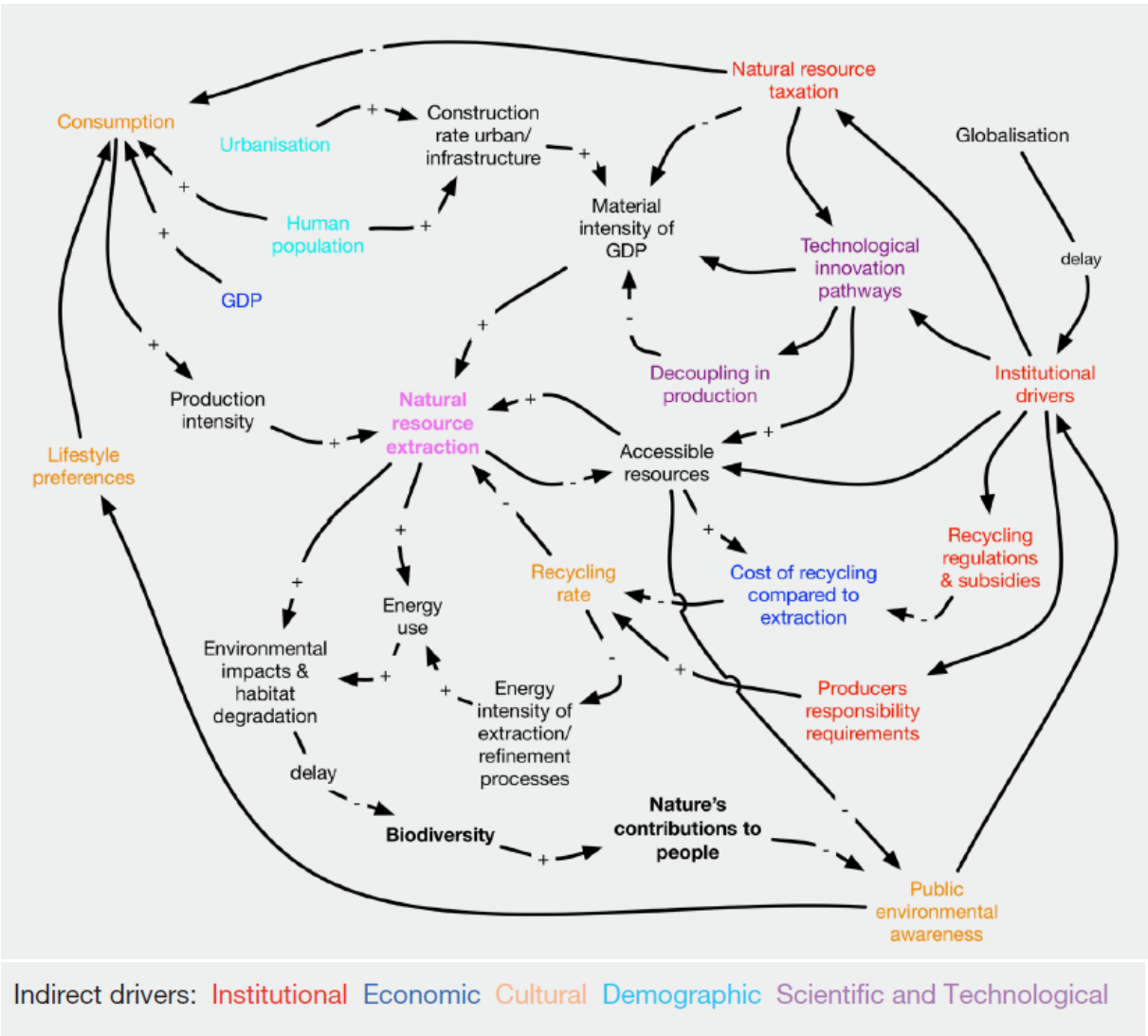


Figure 4.7: Causal loop diagram illustrating drivers of natural resource extraction.

Population changes influence GDP, which drives the rate of production intensity and thereby extraction of natural resources (EEA, 2012c). However, formal institutions drive the taxation of natural resources, which influences the rate of domestic material intensity and the material intensity of GDP (domestic material consumption divided by GDP), affecting extraction rates. Institutional drivers also regulate producers’ responsibility and influence the rate of recycling through regulations and economic incentives. Environmental regulations may restrict availability of natural resources but technological innovation typically increases availability by facilitating extraction (Litovitz, Curtright, Abramzon, Burger, & Samaras, 2013). Finally, institutions like the German energy transformation also influence technological innovation pathways, impacting the material intensity of GDP (Figure 4.7).

Natural resource extraction may result in depletion of natural resources as well as unintended environmental impacts and habitat degradation. These effects may increase public awareness which in turn influences lifestyle preferences and becomes a driver of institutional change (Nolan & Schultz, 2015). Global trade, on the other hand, may disguise these effects and thereby delay institutional responses (4.4.1.3).

In summary, cultural drivers (growth oriented development), demographic and economic drivers (urban sprawl, tourism, consumption etc.) continue exerting a pressure on natural resource extraction in Europe and Central Asia. Institutional drivers have been used to reduce this pressure. However,

18476 economic drivers in terms of environmental taxes have so far not been employed to support these
 18477 advances in institutional drivers and therefore the technological innovative potential is not realized.

18478

18479 4.5 Drivers and effects of land-use change

18480 4.5.1 Effects of land-use change on biodiversity and nature's contributions to people

18481 In Europe and Central Asia land-use change is one of the most important drivers of changes in
 18482 biodiversity and the provision of nature's contributions to people (Aguilar, Ashworth, Galetto, & Aizen,
 18483 2006; CBD, 2014; EEA, 2015c; J. Fischer & Lindenmayer, 2007; Frankham, Bradshaw, & Brook, 2014;
 18484 Garibaldi et al., 2011; Gil-Tena et al., 2015; Gonthier et al., 2014; Jonathan W. Humphrey et al., 2015;
 18485 IPBES, 2016a, 2016b; Leimu, Vergeer, Angeloni, & Ouborg, 2010; Rusch et al., 2016; Tschardt et al.,
 18486 2007)). Mitigating the adverse effects of land-use change is crucial to halting the loss of biodiversity
 18487 and nature's contributions to people (Alkemada et al., 2009; CBD, 2014; Dirzo & Raven, 2003; Hoekstra,
 18488 Boucher, Ricketts, & Roberts, 2005; MA, 2005a).

18489

18490 4.5.1.1 Effects of conventional agricultural intensification

18491 Intensification of conventional agriculture has a multi-factorial impact on biodiversity and nature's
 18492 contributions to people. The actual impacts often vary with an organisms' taxonomic or functional
 18493 group and hence evolutionary history, within and between geographic regions (Báldi, Batáry, & Kleijn,
 18494 2013; Billeter et al., 2008; Flohre et al., 2011; Gabriel, Sait, Kunin, & Benton, 2013; Gonthier et al.,
 18495 2014; Guerrero et al., 2011; IPBES, 2016a; Le Féon et al., 2010; Redhead et al., 2015; Sjödin, Bengtsson,
 18496 & Ekblom, 2008; Tsiafouli et al., 2015; B A Woodcock, Pywell, Roy, Rose, & Bell, 2005). In Europe and
 18497 Central Asia, the impact of conventional intensification of agriculture has been manifest through loss
 18498 of (semi-) natural habitats, landscape homogenization and intensive use of agri-chemicals (Gonthier et
 18499 al., 2014, see Chapter 3). The focus on maximising agricultural production since World War II has
 18500 transformed and modified natural habitats and traditional semi-natural ecosystems physically,
 18501 biologically and chemically with profound implications for biodiversity and nature's contributions to
 18502 people (Gabriel et al., 2013; Gil-Tena et al., 2015; IPBES, 2016a; Sanderson, Kucharz, Jobda, & Donald,
 18503 2013; Stoate et al., 2009; Tschardt et al., 2005; Klein, Kruess, Steffan-Dewenter, & Thies, 2005; UNEP, 2016). For
 18504 example, a negative relationship between crop yield and most elements of biodiversity (plants,
 18505 bumblebees, solitary bees, butterflies, epigeal arthropods) were found in a study of eight paired
 18506 landscapes of organic and conventional management farms (Gabriel et al., 2013). In Europe and
 18507 Central Asia agricultural intensification (defined as the number of pesticide applications, tillage
 18508 operations, fertilizer levels or crop types) relates to reductions in species richness and diversity of
 18509 plants, wild bees and birds, but not ground beetles, at scales from field to region (Billeter et al., 2008;
 18510 Flohre et al., 2011; Le Féon et al., 2010). Among grazed and mown grasslands biodiversity of plants,
 18511 animals and microorganisms declines with increasing mean land-use intensity, while this decline is at
 18512 least ameliorated by variation in land-use intensity between years (E. Allan et al., 2014).

18513 Landscape homogenization is an outcome of conversion of semi-natural habitats based on traditional
 18514 land-use practices into intensively managed arable or grazing land, which has reduced biodiversity and
 18515 a number of nature's contributions to people across Europe and Central Asia (Billeter et al., 2008;
 18516 Flohre et al., 2011; Le Féon et al., 2010; Munteanu et al., 2014; Newbold et al., 2016; Pe'er et al., 2014;
 18517 Stoate et al., 2009; Tschardt et al., 2005; Van Zanten et al., 2014; A. J. Vanbergen, Hails, Watt, &
 18518 Jones, 2006; Adam J Vanbergen, 2014; Yoshihara, Chimeddorj, Buuveibaatar, Lhagvasuren, &

18519 Takatsuki, 2008; H. Zhu et al., 2012). Although large-scale, intensively-managed agricultural
 18520 monocultures can provide food and habitat resources for organisms adapted to exploit it, this resource
 18521 is insufficient to cater for most elements of biodiversity (Diekötter, Peter, Jauker, Wolters, & Jauker,
 18522 2014; IPBES, 2016a; Kovács-Hostyánszki et al., 2013, 2017; Riedinger et al., 2015; Maj Rundlöf, Persson,
 18523 Smith, & Bommarco, 2014; Schweiger et al., 2007; Tscharntke et al., 2005; Adam J. Vanbergen et al.,
 18524 2010; Westphal, Steffan-Dewenter, & Tscharntke, 2009).

18525 Intensive use of agri-chemicals (such as herbicides, insecticides, or inorganic fertilizers) is linked to
 18526 transformation of ecological communities and directly contributes to declines of species, some of
 18527 which providing important contributions to people (Brittain, Bommarco, Vighi, Settele, & Potts, 2010;
 18528 Chiron, Chargé, Julliard, Jiguet, & Muratet, 2014; Deguines et al., 2014; Dormann et al., 2007; Gabriel
 18529 et al., 2013; Gonthier et al., 2014; Hawes et al., 2003; IPBES, 2016a; Maj Rundlöf et al., 2015; Storkey,
 18530 Meyer, Still, & Leuschner, 2012; Ben A. Woodcock et al., 2016). For example, intensive use of herbicides
 18531 and inorganic fertilizers act as environmental filters eliminating wild plant species, especially those
 18532 adapted to conditions of intermediate fertility, with implications for the higher trophic levels, such as
 18533 insect pollinators and seed feeding birds, which depend on such wild plant species for food resources
 18534 (Chiron et al., 2014; Hawes et al., 2003; IPBES, 2016a; Storkey et al., 2012). Further, agricultural
 18535 insecticides target pest populations, they also pose a direct hazard to non-target insects, such as
 18536 pollinators, that are crucial for the maintenance of biodiversity in natural ecosystems and deliver
 18537 important services to pollinator-dependent crops (Deguines et al., 2014; IPBES, 2016a).

18538 Genetically modified crops can possess traits for herbicide tolerance or resistance to pests and their
 18539 large-scale cultivation may drive changes to species and populations in agricultural landscapes either
 18540 directly on gene pools or indirectly on dependent biodiversity. The direct hazard for biodiversity and
 18541 nature's contributions to people is relatively low, although where lethal impacts of insect-resistant
 18542 crops on biodiversity occur they tend to be on species closely related to the targeted pest (IPBES,
 18543 2016a, 2016b; Marvier, McCreedy, Regetz, & Kareiva, 2007; Mommaerts et al., 2010; Nicolia, Manzo,
 18544 Veronesi, & Rosellini, 2014; Simon G. Potts et al., 2016). Reductions of pesticides that may accompany
 18545 the use of insect-resistant crops could lower overall pesticide pressure on non-target organisms, but
 18546 the emergence of secondary outbreaks of non-target pests or primary pest resistance can lead to a
 18547 resumption of pesticide use (Barfoot & Brookes, 2014; IPBES, 2016a, 2016b; Lu et al., 2010). Most risk
 18548 to biodiversity and nature's contributions to people from genetically modified crops comes both from
 18549 their management and direct impacts per se. Intensive herbicide use on herbicide-tolerant crops will
 18550 eliminate wild plants, with concomitant effects on other biodiversity components through the network
 18551 of interactions, although this and the effects on nature's contributions to people remains little-studied
 18552 (Bohan et al., 2005; IPBES, 2016a, 2016b; Morandin & Winston, 2005).

18553 If continued, conventional intensive agriculture will jeopardize both sustainable land management and
 18554 food production. Erosion of natural capital (such as pollinators, natural enemies of pests, soil
 18555 biodiversity and others) poses a substantial risk to the sustained and resilient production of food
 18556 (IPBES, 2016a; Kovács-Hostyánszki et al., 2017; Tsiafouli et al., 2015). Studies focusing on the
 18557 comparison of conventional intensive management with less-intensive agricultural systems indicate
 18558 that there is considerable potential for alternative approaches to management that secure farm
 18559 production and conservation of nature's contributions to people (Bommarco, Kleijn, & Potts, 2013;
 18560 Kovács-Hostyánszki et al., 2017; Richard F. Pywell et al., 2015).

18561

4.5.1.2 *Effects of agri-environment schemes*

A wealth of studies shows that diversity or activity densities at local (field to farm) scales can be enhanced through agri-environment schemes (Albrecht, Duelli, Muller, Kleijn, & Schmid, 2007; Batáry, Báldi, Kleijn, & Tscharntke, 2011; C Carvell et al., 2011; Doxa et al., 2010; Fuentes-Montemayor, Goulson, & Park, 2011; Gonthier et al., 2014; Haaland, Naisbit, & Bersier, 2011; Hiron, Berg, Eggers, Josefsson, & Pärt, 2013; Holzschuh, Steffan-Dewenter, Kleijn, & Tscharntke, 2007; Kovács-Hostyánszki, Korösi, Orci, Batáry, & Báldi, 2011; Krauss, Gallenberger, & Steffan-Dewenter, 2011; R. F. Pywell et al., 2012; Scheper et al., 2013). Certain agri-environmental schemes in the European Union clearly benefit target organisms (e.g. wildflower strips and bees: (Claire Carvell et al., 2017); organic farming and plants: (Batáry, Sutcliffe, Dormann, & Tscharntke, 2013; Henckel, Borger, Meiss, Gaba, & Bretagnolle, 2015; Tuck et al., 2014)). Evidence for increasing biodiversity is sometimes equivocal, complex and unpredictable (e.g. organic farming effects on insects and mammals: Bengtsson, Ahnström, & Weibull, 2005; Gabriel et al., 2010, 2013; Krauss et al., 2011; Ponce, Bravo, de León, Magaña, & Alonso, 2011; Tuck et al., 2014).

Landscape complexity and the ecological contrast with other habitats at field scales influence the efficacy of agri-environment schemes, with typically the greatest uplift in local biodiversity in highly homogenized landscapes that lack remnant semi-natural habitats providing resources for wildlife (Batáry et al., 2011; Gabriel et al., 2010; Heard et al., 2007; Hiron et al., 2013; Holzschuh et al., 2007; Kleijn, Rundlöf, Scheper, Smith, & Tscharntke, 2011; M. Rundlöf & Smith, 2006; Scheper et al., 2013, 2015; Tscharntke et al., 2005; Tuck et al., 2014). Agri-environment schemes have a less expected impact in high-diversity cultural landscapes where they slow down, prevent or even reverse the abandonment process and thus help maintain high nature-value grasslands (Dániel Babai et al., 2015).

Recent evidence points to population-level increases when diverse habitat resources are provided and sustained at the landscape scale (Claire Carvell et al., 2017; Claire Carvell, Bourke, Osborne, & Heard, 2015; Doxa et al., 2010; Tschumi et al., 2016; Wood, Holland, Hughes, & Goulson, 2015). Emerging evidence suggests that targeted habitat creation or protection of ecological infrastructure in the landscape can contribute towards achieving a more sustainable agriculture (Bommarco et al., 2013; IPBES, 2016a, 2016b; Kovács-Hostyánszki et al., 2017; Simon G. Potts et al., 2016; Richard F. Pywell et al., 2015; Tittonell, 2014). There are concerns about the efficacy of agri-environment schemes for conserving rare, specialized species and there is a level of geographic bias in the available evidence (Batáry, Dicks, Kleijn, & Sutherland, 2015; Scheper et al., 2013; L. M. E. Sutcliffe et al., 2015). Effectiveness of agri-environment schemes' interventions could be improved by tailoring to targets for biodiversity or nature's contributions to people considering local ecological and landscape context, and different socio-economic settings (Dániel Babai et al., 2015; Batáry et al., 2015; Bright et al., 2015; Dicks et al., 2016; Ekroos, Olsson, Rundlöf, Wätzold, & Smith, 2014; IPBES, 2016a; Mccracken et al., 2015; Molnár & Berkes, 2017; Pe'er et al., 2014; R. F. Pywell et al., 2012; Scheper et al., 2013; L. M. E. Sutcliffe et al., 2015).

4.5.1.3 *Effects of increasing intensity of management on forest land*

Long-term human pressures during the last centuries (Kolář et al., 2016) have resulted in the deforestation and fragmentation of forests in Europe and Central Asia (e.g., Wallenius, Niskanen, et al., 2010) and will continue to cause species extinctions (I Hanski, 2000; Niemelä et al., 2005). More than 35% of European forests are in mosaic landscapes that are significantly fragmented by agricultural and artificial lands (European Environment Agency, 2016).

One key indicator of high quality habitats is the amount of dead wood. Overall, natural forests normally harbour around 100 m3ha-1 of dead wood (B. G. Jonsson & Siitonen, 2012). Currently, in Western, Central and Eastern Europe, the volume of dead wood in forests is estimated to be 20.5 m3ha-1 (including the Russian Federation) and 10m3ha-1 (without the Russian Federation; Forest Europe (2011)). Among individual countries the volumes vary considerably (Figure 4.8).

Forest management intensification reduces natural forest area and degrades habitat quality due to loss of structural components (e.g. dead wood), simplified spatial stand structure (e.g. uneven age-structure) and simplification of natural processes (e.g. gap formation, decomposition) (Table 4.5). This greatly impacts associated biodiversity, particularly specialist species (Brockerhoff, Jactel, Parrotta, Quine, & Sayer, 2008; Brumelis, Jonsson, Kouki, Kuuluvainen, & Shorohova, 2011; Esseen, Ehnström, Ericson, & Sjöberg, 1997; T Kuuluvainen, 2002; Paillet et al., 2010). For example, species richness of multiple taxa (bryophytes, lichens, fungi, saproxylic beetles, carabids) were considerably lower in managed forests than in unmanaged forests with effects most pronounced for forests that underwent clearcutting and historic changes in tree species composition (Paillet et al., 2010).

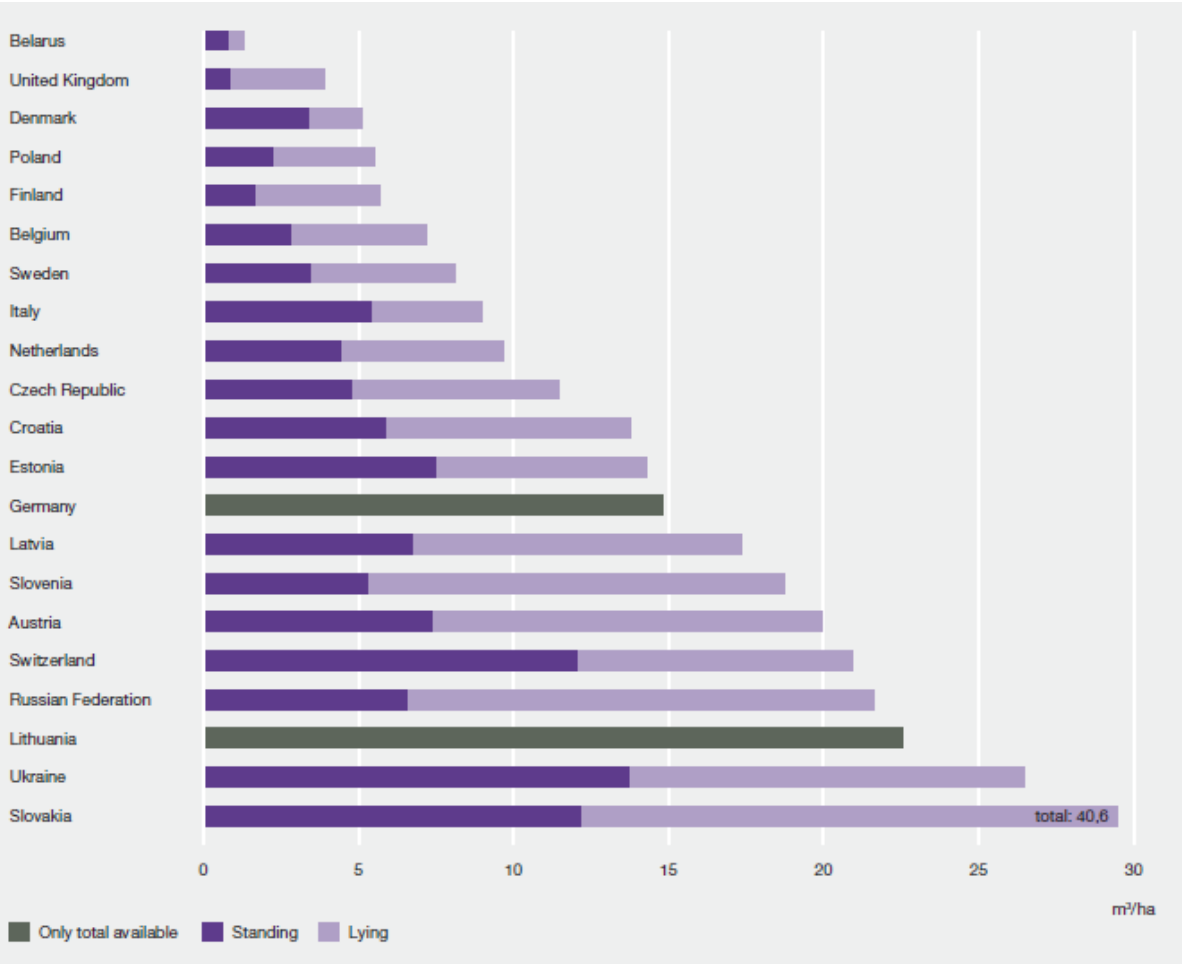


Figure 4.8: Average volume of standing and lying deadwood in 2010 (m3ha-1) (Forest Europe, 2011).

Table 4.5: Components that are important for biodiversity in natural forests that are negatively influenced by forestry (modified after (Esseen et al., 1997)).

Structural components

Very old trees
 Trees with abundant growth of epiphytes
 Broken, stag-headed and leaning trees
 Trees with holes, cavities and other microhabitats
 Dead standing trees (snags)
 Fire-scarred trees, snags and stumps
 Large downed logs in various stages of decomposition

Spatial patterns

A developed understory of tree saplings and shrubs
 Mixed stands, with both conifers and broad-leaves
 Uneven-aged stand structure
 Multi-layered tree canopies
 Patchy distribution of trees, gaps

Processes

Post-fire succession
 Succession with tree-species replacement
 Self-thinning
 Gap formation
 Snag and log formation
 Decomposition of coarse woody debris

18625

18626 Intensive forest management also includes conversion of non-forested lands to managed forest
 18627 plantations, which often have detrimental effects on in situ biodiversity due to loss of habitat and
 18628 associated species turnover (Brockerhoff et al., 2008). However, afforestation of agricultural land can
 18629 assist biodiversity conservation by providing ecotones and increasing forest connectivity (Brockerhoff
 18630 et al., 2008). Where forest cover is low, plantation on marginal land can provide habitats for rare forest
 18631 adapted species (J. Humphrey, Ferris, & Quine, 2003). Additional conservation efforts to improve
 18632 forest structure can correspondingly improve the situation for biodiversity (J. W. Humphrey, 2005).
 18633 Traditionally managed and used forest ecosystems such as traditional agro-silvicultural systems with
 18634 wood-pastures and coppicing also support and maintain suitable conditions for many forest species
 18635 (Bollmann & Braunisch, 2013; Keith Kirby & Watkins, 2015; Tobias Plieninger et al., 2015). As different
 18636 types of forest management promote different facets of biodiversity or nature's contributions to
 18637 people, heterogeneity of forest management practice at the landscape scale, also including
 18638 unmanaged forest, is likely to maximize landscape-level forest biodiversity and forest contributions to
 18639 people (Elbakidze et al., 2017; van der Plas et al., 2016).

18640

18641 *4.5.1.4 Effects of decrease in land area with traditional land use and loss of traditional ecological* 18642 *knowledge*

18643 Much of the biodiversity in Europe and Central Asia relies on traditionally managed semi-natural
 18644 habitats (EEA, 2015b; Keith Kirby & Watkins, 2015; Liira, Aavik, Parrest, & Zobel, 2008; Tobias
 18645 Plieninger et al., 2015; Stoate et al., 2009; Tschardt et al., 2005; UNEP, 2016). The loss and
 18646 abandonment of traditionally managed systems due to multiple factors has been an important driver
 18647 of decline in biodiversity and nature's contributions to people (Bergmeier, Petermann, & Schröder,
 18648 2010; Bubová, Vrabec, Kulma, & Nowicki, 2015; Fuller, 1987; Helm, Hanski, & Pärtel, 2006; Henle et
 18649 al., 2008; MacDonald et al., 2000; Middleton, 2013; Tobias Plieninger et al., 2015; Rotherham, 2015;
 18650 van Swaay, Warren, & Loïs, 2006). Abandonment of traditional land management allows reassertion

of successional and other ecological processes (e.g. increase in interspecific competition) leading to loss of specific habitats that support biodiversity of high conservation value (Bergmeier et al., 2010; Middleton, 2013; Rotherham, 2015). The evidence for a negative impact of abandonment is particularly strong for semi-natural grassland systems (Bergmeier et al., 2010; Dengler, Janišová, Török, & Wellstein, 2014; Rotherham, 2015), mountainous areas (MacDonald et al., 2000) and for particular taxa (e.g. butterflies, farmland birds and plants, van Swaay et al. (2006), Bubova et al. (2015), Liira et al. (2008)). Since World War II, the cover of open cultural woodlands in Western and Central Europe has rapidly declined and been replaced with agricultural fields and closed forests. This led to a decline in light-dependent specialist species of open woodland and increases in species typical for mesic and closed forest (Bütler, Lachat, Larrieu, & Paillet, 2013; Hédli, Kopecký, & Komárek, 2010; Miklín & Čížek, 2014; Nieto & Alexander, 2010; Tobias Plieninger et al., 2015; Saniga, Balanda, Kucbel, & Pittner, 2014; van Swaay et al., 2006). There are cases where taxa benefit from abandonment of semi-natural habitats ((Gulvik, 2007) for Oribatid mites, (Sitzia, Semenzato, & Trentanovi, 2010)) but these seem to be the exception. Abandonment and loss of semi-natural habitats have also significant negative impacts on cultural and social capital and results in loss of traditional and local knowledge (Csgero, Demeter, & Turkington, 2013; Zs Molnár & Berkes, 2017; Rotherham, 2015). The precise outcome often depends upon the direction of the succession (e.g. to steppe vs to forest, (Dengler et al., 2014), or above vs below the treeline, (MacDonald et al., 2000)), the spatial context (Sitzia et al., 2010), the time since abandonment (Lasanta, Nadal-Romero, & Arnáez, 2015), and the pattern of farming (MacDonald et al., 2000).

4.5.1.5 Effects of urban development

The expansion of urban areas and its pressure on natural and semi-natural land will continue to be one of the major land-use factors in large parts of Western and Central Europe (EEA, 2016c), and is also likely to result in considerable land take in Central Asia in coming decades (Angel, Parent, Civco, Blei, & Potere, 2011). With increasing urbanization, direct destruction of habitats, reduction of habitat areas, increasing fragmentation and degradation in both terrestrial and aquatic habitats can lead to significant negative impacts on biodiversity (Güneralp & Seto, 2013; McKinney, 2006, 2008). Urbanization affects different habitats and species groups disproportionately and often its effects are related to intensity of urbanization and regional biodiversity patterns (McKinney, 2008). In regions with less effective governance of land use, there is a greater possibility of development affecting areas with high biodiversity (Güneralp & Seto, 2013). In Western and Central Europe, urban development and its associated land take poses a major threat to soil and could have significant effects on agricultural production and food (Gardi, Panagos, Van Liedekerke, Bosco, & De Brogniez, 2015).

4.5.1.6 Effectiveness of landscape and habitat restoration

Restoration success depends on the ability to encompass the important ecological mechanisms that underpin ecosystem functioning (Török & Helm, 2017). For example, forest restoration success has been shown to mainly depend on time since restoration initiation, disturbance type (secondary or selectively logged forests) and landscape context (e.g. forest patch size and isolation; (Crouzeilles et al., 2016). It is important to restore the genetic diversity contained within an ecosystem to assure evolutionary potential and to avoid adverse effects caused by management, e.g. founder effects, where only few individuals contribute to initial genetic diversity (Brudvig, 2011; Mijangos, Pacioni, Spencer, & Craig, 2015; Wortley, Hero, & Howes, 2013) (see **Box 4.2**).

There are numerous links between restoration, economic development, and human well-being (Aronson et al., 2010; José M. Rey Benayas, Newton, Diaz, & Bullock, 2009) (see **Box 4.2**). Successful engagement of local community and other social attributes are considered highly important in determining the feasibility and cost of restoration, as well as the success of restoration and sustainability of the restoration outcome (Shackelford et al., 2013; Wortley et al., 2013).

Rewilding is a particular approach that aims to restore ecosystems toward a state of wilderness (Carey, 2016). The effects of rewilding on biodiversity and nature's contributions to people likely depend on initial conditions before rewilding and on the success of development of self-sustainable ecosystems. Sufficient evidence for suitable solutions is not yet available (Cerqueira et al., 2015; S. J. Dixon, Sear, Odoni, Sykes, & Lane, 2016; Götmark, 2013; Smit, Ruifrok, van Klink, & Olff, 2015; Ziolkowska & Ziolkowski, 2016). There is a potential for conflict as many proposed rewilding areas (see Ceaușu et al., 2015) lie in regions where indigenous peoples and local communities live (e.g. Carpathians, Balkan). Considering human rights and the rights of these communities during the establishment of rewilding areas is of vital importance.

Box 4.2: Restoration of grasslands has brought people back to the countryside



Sheep on recently restored alvar grassland in Saaremaa, Estonia. Following the abandonment of traditional land use, large part of Estonian semi-natural grasslands overgrew with shrubs. Restoration of those species rich grasslands and subsequent grazing, supported by agricultural subsidies, has led to positive impacts on both the local livelihood and on biodiversity. Photo: Ants Animägi, Estonian State Forest Management Centre.

Alvars, dry calcareous thin-soiled semi-natural grasslands once covered ca 50 000 hectares in western part of Estonia, especially on its scenic islands Saaremaa, Muhu and Hiiumaa (Helm, Urbas, & Pärtel, 2007). By 2013, only 2500 hectares were managed by grazing – a traditional management method necessary for the persistence of these high nature value habitats (Estonian Ministry of Environment, 2013). In an effort to save high biodiversity and traditional land-use practices related to Alvar grasslands, 600 land-owners and 41 local farmers and farming companies in 25 regions all over western part of Estonia are participating in the LIFE+ program project “LIFE to Alvars” (LIFE13NAT/EE/000082) from 2014 to 2020. Project aims to double the area of managed Alvars in Estonia by restoring 2500 hectares of grasslands and encouraging local people and farmers to take up grazing in those areas. Already by 2017, restoration activities, vastly changing landscapes and awareness-raising activities have had considerable impact both on the public knowledge about the value of grasslands, as well as on economic

and lifestyle choices among local people. Implementation of the infrastructure necessary for grazing (fences, animal drinking places and shelters, gates), coupled with the support system for managing semi-natural areas have created incentives for local farmers to increase their livestock and move animals from cultural grasslands to restored Alvars. By 2017, following the restoration of the first 1500 hectares of traditional grassland landscapes, 270 head of cattle and 400 sheep were added to the herds of local farmers. In addition, four families moved back to the countryside and changed their profession to livestock farmers. Open Alvar grasslands have great aesthetic, cultural heritage and recreational value and several nearby tourism facilities noted the positive effect of grassland restoration on their activities, by boosting visitor numbers and by increasing the opportunities on offer for scenic nature tours (Prangel, 2017).

End of Box 4.2

4.5.1.7 Effectiveness of protected areas

Designated conservation areas are highly important in safeguarding biodiversity and nature's benefits to people, but there is considerable evidence that protected areas alone cannot prevent biodiversity loss (e.g. Mora & Sale, 2011), particularly for migratory species (e.g. Saiga antelope, Bull, Suttle, Singh, & Milner-Gulland, 2013) or habitats or species particularly sensitive to environmental change (Bull et al., 2013; N. Dudley, Groves, Redford, & Stolton, 2014; Strayer & Dudgeon, 2010). A global systematic review shows that individual protected areas were effective at protecting habitats, particularly forests, but less effective at conserving populations of species (Geldmann et al., 2013). There is great variation across Europe and Central Asia in the efficacy of formally protected areas for biodiversity conservation. Recent evaluations of the European Union Natura 2000 network of protected areas found it to be effective in providing coverage to most species listed in Annex II of the Habitats Directive (http://ec.europa.eu/environment/nature/legislation/fitness_check/docs/nature_fitness_check.pdf).

Natura 2000 sites do not only therefore serve the purpose of protecting Annex 1 (Birds Directive) and Annex 2 (Habitats Directive) species, but also protect certain more common (non-Annex) species, in particular breeding birds and butterflies, but less so amphibians and reptiles (T. van der Sluis et al., 2016). However, the Natura 2000 network is not completely effective because there are exceptions for particular taxa (e.g., Zehetmair, Müller, Runkel, et al., 2015; Zehetmair, Müller, Zharov, & Gruppe, 2015) or in the way different member States implement it. For example, certain species (e.g. those dependent on traditional land management) or ecological zones (e.g. lowland versus upland) were either over- or under-represented, and gaps exist in the protection of biodiversity in certain habitats (e.g. marine and temporary freshwater habitats) (Gruber et al., 2012; Maiorano, Falcucci, Garton, & Boitani, 2007; McKenna, Naumann, McFarland, Graf, & Evans, 2014; T Van der Sluis, Jongman, Bouwma, & Wascher, 2012).

Natura 2000 represents one of the most systematic efforts for developing new protected areas, but the effectiveness of implementation of Natura 2000 for biodiversity conservation has not been sufficiently evaluated (Gaston, Jackson, Nagy, Cantú-Salazar, & Johnson, 2008). A major challenge for forest protected areas is that current conditions are not pristine due to past management and suppression of natural disturbance processes (Hedwall & Mikusiński, 2015; Löhmus, Kohv, Palo, Viilma, & Lohmus, 2004; Meyer et al., 2011). Protected areas also tend to be too small to accommodate the full range of natural processes and hence unable to maintain sufficient ecological memory to re-organize after disturbances (Bengtsson et al., 2003). In some forest reserves, "natural" state is contingent on traditional management (e.g. livestock grazing, coppicing, pollarding or small-scale felling). The introduction of such methods may be needed to secure forest biodiversity, but is so far rarely implemented mainly for economic reasons (Bernes et al., 2015; Götmark, 2013; Sebek, Altman, Platek, & Cizek, 2013). Measures to improve environmental status within conservation areas,

18771 combined with landscape-scale approaches that improve matrix quality for native biodiversity, are
18772 therefore urgently needed if their efficiency is to be improved.

18773 The degree of monitoring and enforcement of protected areas can be critical for their efficacy in
18774 protecting biodiversity (e.g. Wendland, Baumann, Lewis, Sieber, & Radeloff, 2015). For instance,
18775 almost 40% of the protected areas in the Barents Euro-Arctic region remain vulnerable to disturbance
18776 from human activities, including logging, mining, drilling and construction (Aksenov, Kuhmonen,
18777 Mikkola, & Sobolev, 2014). The efficacy of protection often varies among countries. For example,
18778 protected forest areas in the eastern Carpathians have proved effective at halting illegal logging in
18779 Poland and Slovakia but have been less so in Ukraine (Kuemmerle, Hostert, Radeloff, Perzanowski, &
18780 Kruhlov, 2007) and protection in one country can lead to displacement of adverse impacts to adjoining
18781 territories (Mayer, Kauppi, Tikka, & Angelstam, 2006). In certain circumstances, proximity to humans
18782 can sometimes affect the efficacy of protected areas in conserving biodiversity. For example, in
18783 Kyrgyzstan proximity of villages to protected areas was linked to a lowering of effectiveness for
18784 conserving non-ungulate large mammals (McCarthy, McCarthy, Fuller, & McCarthy, 2010). In eastern
18785 Russia, Siberian tiger survival was inversely linked to roads bordering or crossing the strictly protected
18786 Sikhote-Alin State Biosphere Zapovednik (Kerley et al., 2002). In summary, the proportion of protected
18787 areas is an important indicator of conservation efforts, although it needs to be combined with other
18788 indicators to fully assess the efficacy of measures aiming to conserve biodiversity (e.g. management
18789 plans, restoration actions, population indices of target species etc.).

18790 The European Union Biodiversity Strategy Target 1 (“fully implement the Birds and Habitats
18791 Directives”) and Target 2 (“maintain and restore ecosystems and their services”) define actions to
18792 ensure habitats and ecosystems protection. There is a progress on those targets in the European
18793 Union, but in insufficient rate: 16% of the habitats assessments are favourable, 4% are unfavourable,
18794 but improving, 33% are unfavourable and stable, 30 % are unfavourable and deteriorating, 10% are
18795 unfavourable with unknown trend and 7% are unknown (Mid-term Review of the European Union
18796 Biodiversity Strategy, 2015). The network of Natura 2000 sites has progressed and is largely completed
18797 for terrestrial habitats, since 2010 it has grown for 1,4% and covering in 2015 18,1% of the European
18798 Union land. Overall, the mid-term assessment indicates the progress as the one with an insufficient
18799 rate (European Commission, 2015). Therefore, the European Union Biodiversity Targets 1 and 2 may
18800 not to be fully met by 2020 if the rate of the progress remains at the current level.

18801 Regarding the Aichi Biodiversity Targets, reaching Target 11 (“protected areas increased and
18802 improved”) for terrestrial ecosystems implies an increase in terrestrial protected areas, with an
18803 increased focus on representativeness and management effectiveness (Leverington, Hockings, Pavese,
18804 Costa, & Courrau, 2008). A focus on representativeness is crucial as current protected area networks
18805 have gaps, and some fail to offer adequate protection to many species and ecosystems. These gaps
18806 include many sites of high biodiversity value such as Alliance for Zero Extinction sites and Important
18807 Bird Areas (Butchart et al., 2010; Ricketts et al., 2005). The global data sets statistically prove the
18808 progress in the increased coverage of protected area and sites of significance that ensure ecosystems
18809 connectedness in Europe and Central Asia. The data includes the World Database on Protected Areas
18810 (WDPA)(IUCN and UNEP-WCMC, 2014), Data on sites contributing significantly to the global
18811 persistence of biodiversity, or “key biodiversity areas” (KBAs) are provided by BirdLife International
18812 (2017) for Important Bird & Biodiversity Areas and by the Alliance for Zero Extinction sites holding the
18813 entire population of at least one highly threatened species (Brooks et al., 2006; Ricketts et al., 2005).

18814

18815 4.5.2 Trends and indirect drivers of changes in agricultural land use

18816 4.5.2.1 Trends in agricultural land use

18817 Agricultural land-use changes are constrained and driven by biophysical conditions and sets of inter-
18818 related indirect drivers (e.g. policies, political changes in Eastern Europe and Central Asia, demands for
18819 food and ecological products etc.). Across the region there are two principal trends: (1) intensification
18820 of conventional agriculture; and (2) decreasing land-use intensity and abandonment of conventional
18821 agricultural land.

18822 Trend 1: Intensification of conventional agriculture.

18823 This model of agricultural production is characterized by large-scale monocultures specializing on few
18824 crops that are supported by high levels of agrichemical inputs or irrigation, management of high
18825 livestock densities, and mechanization to increase production (Foley et al., 2005; Goldewijk, 2001;
18826 Henle et al., 2008; R. A. Robinson & Sutherland, 2002; D. Tilman et al., 2001; Tscharntke et al., 2005;
18827 van Vliet et al., 2015; EEA, 2015). Agricultural intensification has been a dominant driver of land-use
18828 changes in Europe and Central Asia since the 1950s (Jepsen et al., 2015; EEA, 2015). The area of
18829 agricultural holdings and their role in the agricultural sector are constantly growing (BEFL, 2016;
18830 Petrick, Wandel, & Karsten, 2013; O. Visser, Mamonova, & Spoor, 2012; O. Visser, Spoor, & Mamonova,
18831 2014). They are especially large in the most favourable regions for agriculture. For example, in Russia
18832 43 companies cultivate in total 10.4 million hectares (BEFL, 2016). Although the temporal and spatial
18833 patterns and intensity of agricultural land use vary considerably within the region, intensive agriculture
18834 is expected to remain among the prevailing land-use practices in the region into the future (Jepsen et
18835 al., 2015).

18836 In Western Europe, conventional intensive agriculture has been the prevailing model of agricultural
18837 production since the 1950s (EEA, 2015a). This has led to considerable landscape homogenization
18838 (Curado, Hartel, & Arntzen, 2011; Stoate et al., 2009). Landscape homogenization also occurred in
18839 many parts of Central Europe during the socialist period (1945 – 1990) (Fraser & Stringer, 2009;
18840 Munteanu et al., 2014). In Eastern Europe and Central Asia, Russia, Ukraine and Kazakhstan,
18841 conventional agricultural intensification happened mainly after the break-up of the USSR in 1991; and
18842 these three countries became major exporters of agricultural products (M. Liefert, Liefert, &
18843 Serova, 2009). Currently, Russia is among the major world grain exporting nations due to an increase
18844 of land-use intensity and partial re-cultivation of abandoned lands after 2000 (Medetsky, 2016).

18845 In Central Asia irrigated agricultural areas have increased at the expense of natural pastures since the
18846 1960-1970s, for instance in the vicinity of the Syr Darja and Amur Darja rivers. This is mainly due to
18847 cotton production (Kaplan, Blumberg, Mamedov, & Orlovsky, 2014), which has doubled since the
18848 1960s and now accounts for nearly half of all irrigated arable land. Irrigation is currently used for 33%
18849 (13 million ha) of cultivated areas in Central Asia. However, poor maintenance of drainage systems has
18850 resulted in millions of hectares of irrigated areas suffering from salinization and waterlogging. In
18851 Uzbekistan 51% (2.1 million ha) and Turkmenistan 68% (1.3 million ha) of irrigated areas are salinized
18852 and further widespread degradation of agricultural land is expected in these countries (Frenken, 2013;
18853 Horion et al., 2016).

18854 Trend 2: Decrease of land-use intensity and abandonment of conventional agricultural land

18855 Agricultural land abandonment is widespread in Europe and Central Asia (J. M. R. Benayas, Martins,
18856 Nicolau, & Schulz, 2007; G. I. Díaz, Nahuelhual, Echeverría, & Marín, 2011; A. V. Prishchepov et al.,
18857 2013; C. Wang, Gao, Wang, & Yu, 2016). The available evidence indicates that it is reasonable to expect
18858 that farmland abandonment will continue over the next few decades, particularly in the case of

extensively grazed lands (Keenleyside & Tucker, 2010). However, some projections of land-use change are limited by a lack of appropriate data on historical legacies, local conditions and drivers (Biró et al., 2013; Feranec, Jaffrain, Soukup, & Hazeu, 2010; Hatna & Bakker, 2011; Temme & Verburg, 2011). Overall, the largest abandonment extent is in the East European forest steppe and Pontic steppe zones, in Sarmatic mixed forests and in the boreal zone (Schierhorn et al., 2013a).

Agricultural land abandonment leads to complete termination of agricultural activity and reforestation through silviculture or natural succession to shrubs and forest (Alcantara, Kuemmerle, Prishchepov, & Radeloff, 2012; Baldock, Beaufoy, Selby, Guiheneuf, & Manterola, 1996; M. Baumann et al., 2011; van der Zanden, Verburg, Schulp, & Verkerk, 2017). For example, in Western and Central Europe an increase of forest and semi-natural habitats after abandonment of agricultural land occurred widely in Italy, Hungary, Poland and Germany and to a lesser extent in France and Greece, while in Spain the transition was in the opposite direction (Petersen, 2006). Agricultural land abandonment has tended to be concentrated in areas that are marginal for agriculture, for example, on unproductive soils and areas limited by other biophysical conditions (temperature, high precipitations etc.) (Grigory Ioffe, 2005; Meyfroidt, Schierhorn, Prishchepov, Müller, & Kuemmerle, 2016; Alexander V. Prishchepov et al., 2016)(A. V. Prishchepov et al., 2013). Abandoned farmland was converted to urban residential areas or infrastructure in some places or, more often, became forested or afforested (Grădinaru et al., 2015; Plutzar et al., 2015; Schierhorn et al., 2013b).

In the European Union cropland area has decreased by almost 1.2 million hectares in recent decades (J. M. Dixon, Donati, Pike, & Hattersley, 2009; Grădinaru et al., 2015; Munton, 2009). In Central European countries, including Poland, Czech Republic, Slovakia, Hungary, Romania and Bulgaria, during the 1990s and 2000s the prevailing land-use trend was abandonment of arable land and grassland, reductions of livestock densities and agrochemical use and reforestation (Biró et al., 2013; L. Sutcliffe, Paulini, Jones, Marggraf, & Page, 2013). For example, in Poland 17.6%, in Estonia 10.1% and in Latvia 21.1% of agricultural land was abandoned by 2002 (Keenleyside & Tucker, 2010). However, expansion of the European Union and implementation of its Common Agricultural Policy in new member States has resulted in the reclaiming of abandoned farmland for intensive agriculture – a trend that is likely to continue (Keenleyside & Tucker, 2010; Kuemmerle, Müller, Griffiths, & Rusu, 2009; L. Sutcliffe et al., 2013).

Eastern Europe and Central Asia have been hotspots of cropland abandonment since the 1990s (Keenleyside & Tucker, 2010; Kuemmerle et al., 2009; L. Sutcliffe et al., 2013). The collapse of the socialistic collective farming system resulted in the abandonment of more than 58 million hectares of former croplands in Russia and Kazakhstan (Kurganova, Lopes de Gerenyu, & Kuzyakov, 2015) (**Figure 4.9** and **Figure 4.10**). This was mirrored by substantial reductions in livestock (e.g. >30% reductions from 1990 levels in cattle densities in 2005 and 2015) (Chibilyov (Jr.), 2016; Lescheva & Ivolga, 2015; Rosstat, 2017). In Kazakhstan and in stock farming steppe regions of Russia the collapse of livestock populations and state farms were combined with the private acquisition of former state assets, including livestock (Carol Kerven, Robinson, Behnke, Kushenov, & Milner-Gulland, 2016; S. Robinson, Kerven, Behnke, Kushenov, & Milner-Gulland, 2016; Suleimenov & Oram, 2000). Livestock declines of up to 80% in sheep and cattle took place in Kazakhstan (Kamp, Urazaliev, Donald, & Hölzel, 2011), creating a vast area of un-grazed grasslands (Carol Kerven et al., 2016). Grazing patterns changed significantly, and intensive grazing became restricted to areas around villages, which have been rapidly degrading due to overgrazing (Kamp et al., 2012, 2011; Kandalova & Lysanova, 2010; Kitov & Tsapkov, 2015; Kühling, Broll, & Trautz, 2016; Morozova, 2012; Suleimenov & Oram, 2000).

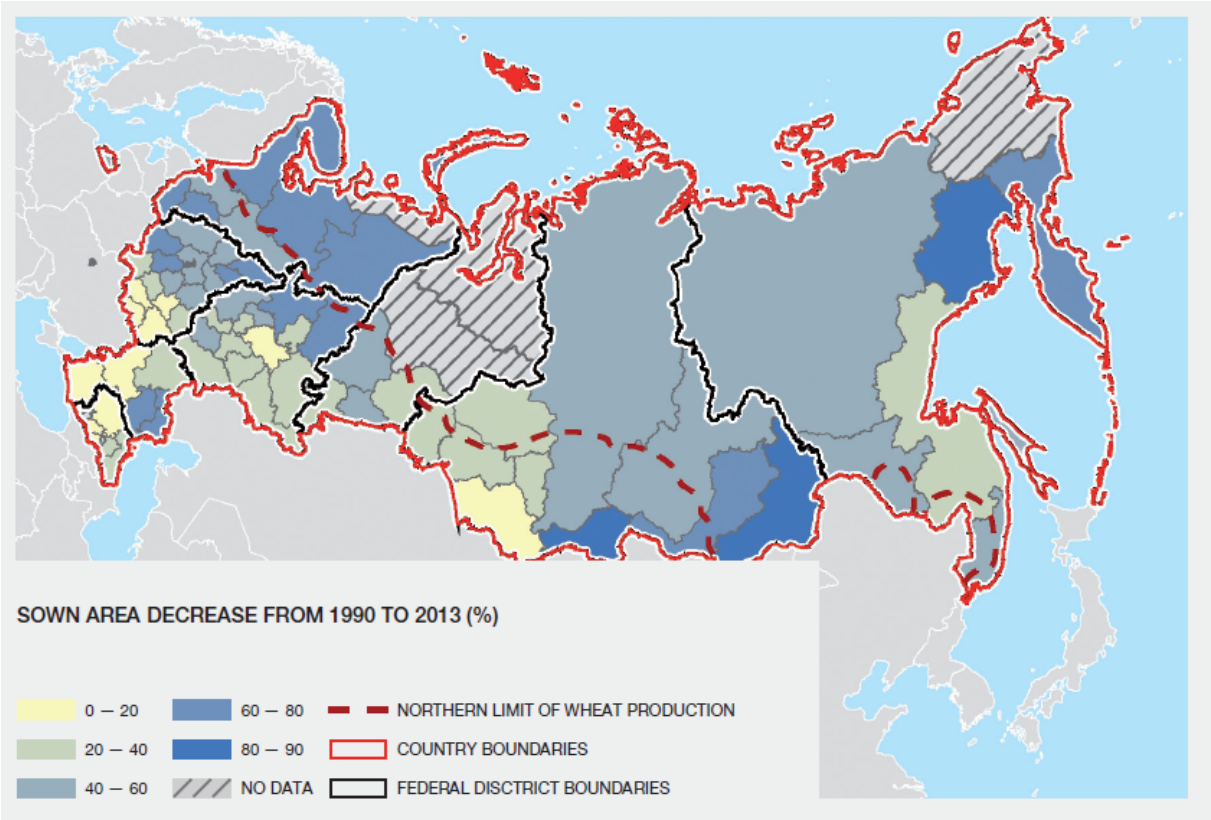


Figure 4.9: Decrease in sown area from 1990 to 2013 across Russia, Ukraine and Kazakhstan (CISSTAT, 2017).

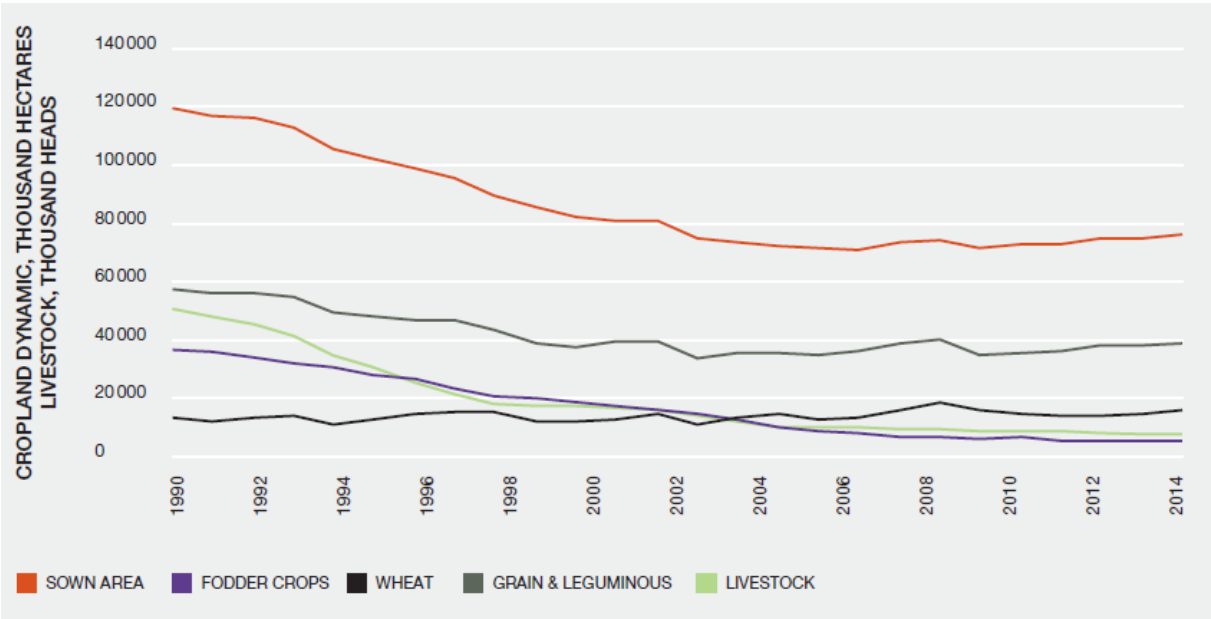


Figure 4.10: Change in cropland areas and livestock numbers in Eastern Europe and Central Asia (Data source: CISSTAT, 2017; ESTstat, 2017; LATVstat, 2017; LITHstat, 2017).

4.5.2.2 Indirect drivers of trends in agricultural land use

Changes in agriculture are driven by multiple interconnected institutional, economic, cultural and technological drivers (**Figure 4.11**).

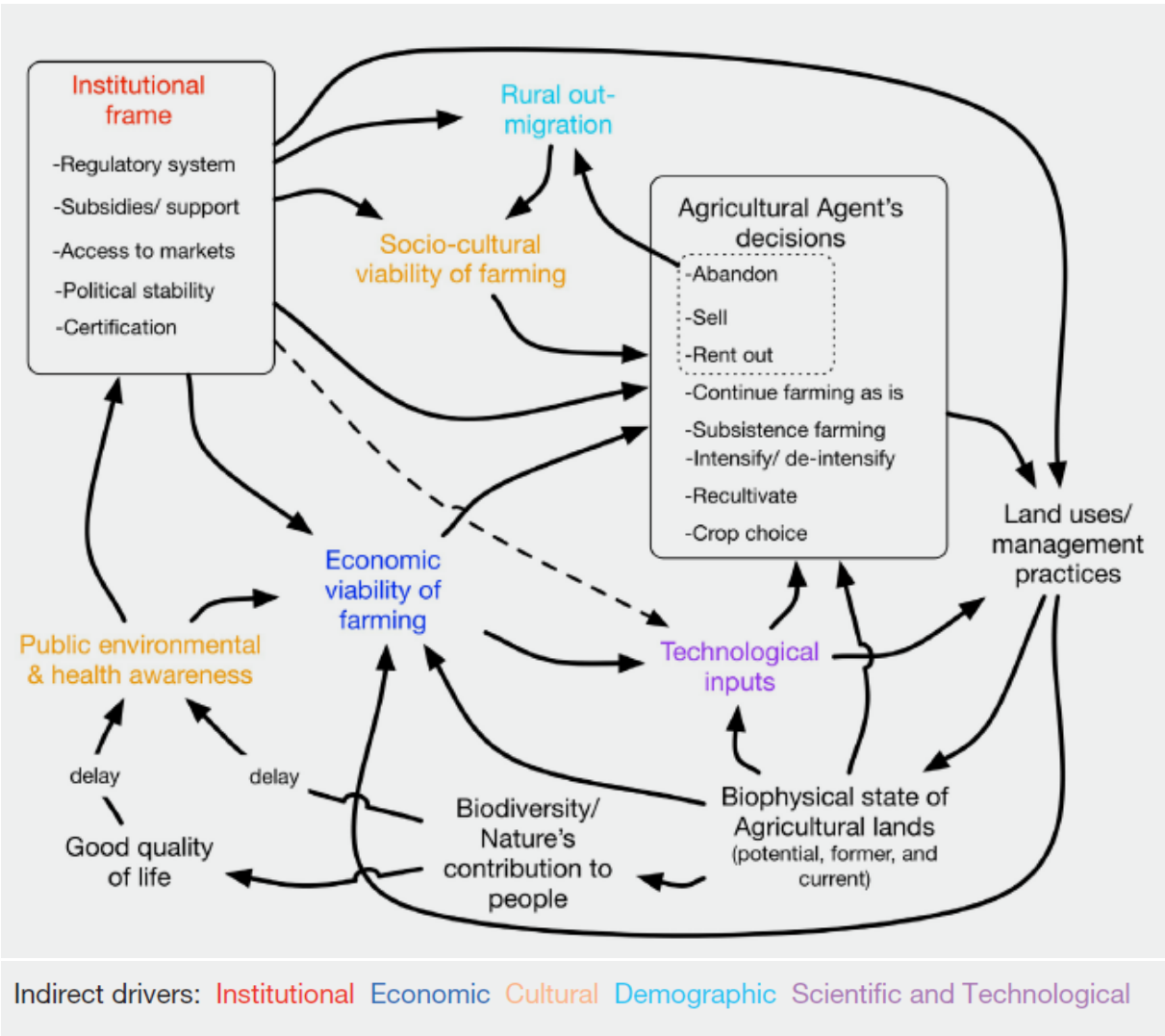


Figure 4.11: An illustration of the key drivers and systemic interconnections dominating agricultural land-use change in Europe and Central Asia (own illustration). The specific ensemble of land uses and agricultural practices employed on a given farm are largely the aggregate of a set of decisions made by the agricultural agent, which in turn are shaped by the economic and socio-cultural viability of farming in the region, the availability of technological inputs, as well as the institutional frame in which agriculture is situated. These inter-relationships are further unpacked in a series of sub-models below (see further figures).

4.5.2.2.1 Institutional drivers of trends in agricultural land use

Until the 1980s, the European Union Common Agricultural Policy became the major incentive for the conventional intensification of agriculture (Van Zanten et al., 2014) through a subsidy scheme based primarily on price pegging. Since 1992, it has increasingly been adapted to better serve the aims of sustainability by means of a fundamental reform process designed to move away from a policy of price and production support to a policy of direct income aid and rural development measures, including agri-environmental schemes. The 2003 Common Agricultural Policy reform (Council Regulation (EC) No 1782/2003) brought forward environmental concerns in agriculture. It reinforced a number of measures that encourage land use and practices compatible with the protection of environmental resources. Agri-environmental schemes became compulsory for every member State.

18933 From the 1990s, in Central Europe radical changes in political, social and economic systems brought
 18934 about the restitution of private property and the land market with consequential economic drivers.
 18935 State support diminished, former export markets within the socialist sphere of influence disappeared,
 18936 prices were liberalized, and farmers suddenly faced strong external competition even though they
 18937 often lacked the necessary inputs (e.g., fertilizer) and technology (e.g., access to machinery) to sustain
 18938 high yields (Lerman, Csaki, & Gershon, 2004; Rozelle & Swinnen, 2004; Skokanová, Falťan, & Havlíček,
 18939 2016). These politico-economic drivers instigated further agricultural intensification in fertile regions,
 18940 and abandonment of less fertile or less accessible land (Fonji & Taff, 2014; Jepsen et al., 2015;
 18941 Skokanová et al., 2016; van Vliet et al., 2015). During the transition from planned to market economy
 18942 the agricultural cooperatives were dismantled and much of their land was privatized to new owners
 18943 or re-privatized to the former owners, which led to establishment of numerous smallholder farms.
 18944 Many smallholders had no interest or knowledge, or adequate financial resources and equipment to
 18945 profitably cultivate the agricultural land and thus quit farming or resorted to subsistence farming on
 18946 small parcels of land scattered across the landscape (Biró et al., 2013). The rapid privatization
 18947 (Skokanová et al., 2016), ownership insecurity (e.g. in Romania, see (Kuemmerle et al., 2009), and a
 18948 lack of interest or knowledge in agriculture of the new landowners resulted in large-scale land
 18949 abandonment and decreased management intensity in large areas of Central Europe (Liira et al., 2008;
 18950 Palang & Printsmann, 2010; Theo van der Sluis, Pedroli, Kristensen, Lavinia Cosor, & Pavlis, 2015; van
 18951 Vliet et al., 2015). After 2004, when many Central European countries joined the European Union, the
 18952 land tenure system stabilized through the introduction of the European Union Common Agricultural
 18953 Policy, which has helped to restore farming activities in many areas, especially mountain regions, and
 18954 has stabilized agricultural development in some countries of Central Europe (Bezák & Mitchley, 2014;
 18955 Ruskule, Nikodemus, Kasparinskis, Bell, & Urtane, 2013; Theo van der Sluis et al., 2015). Agricultural
 18956 subsidies introduced with the accession to the European Union increased the economic viability of
 18957 agricultural land, leading to agricultural expansion and intensification. Agricultural subsidies, however,
 18958 also caused problems as they enhanced regional inequality by excluding small-scale farmers in remote
 18959 areas (Bezák & Mitchley, 2014) or by causing damage to areas of conservation interest (e.g. ploughing
 18960 high-diversity grasslands and meadows) (**Figure 4.12**).

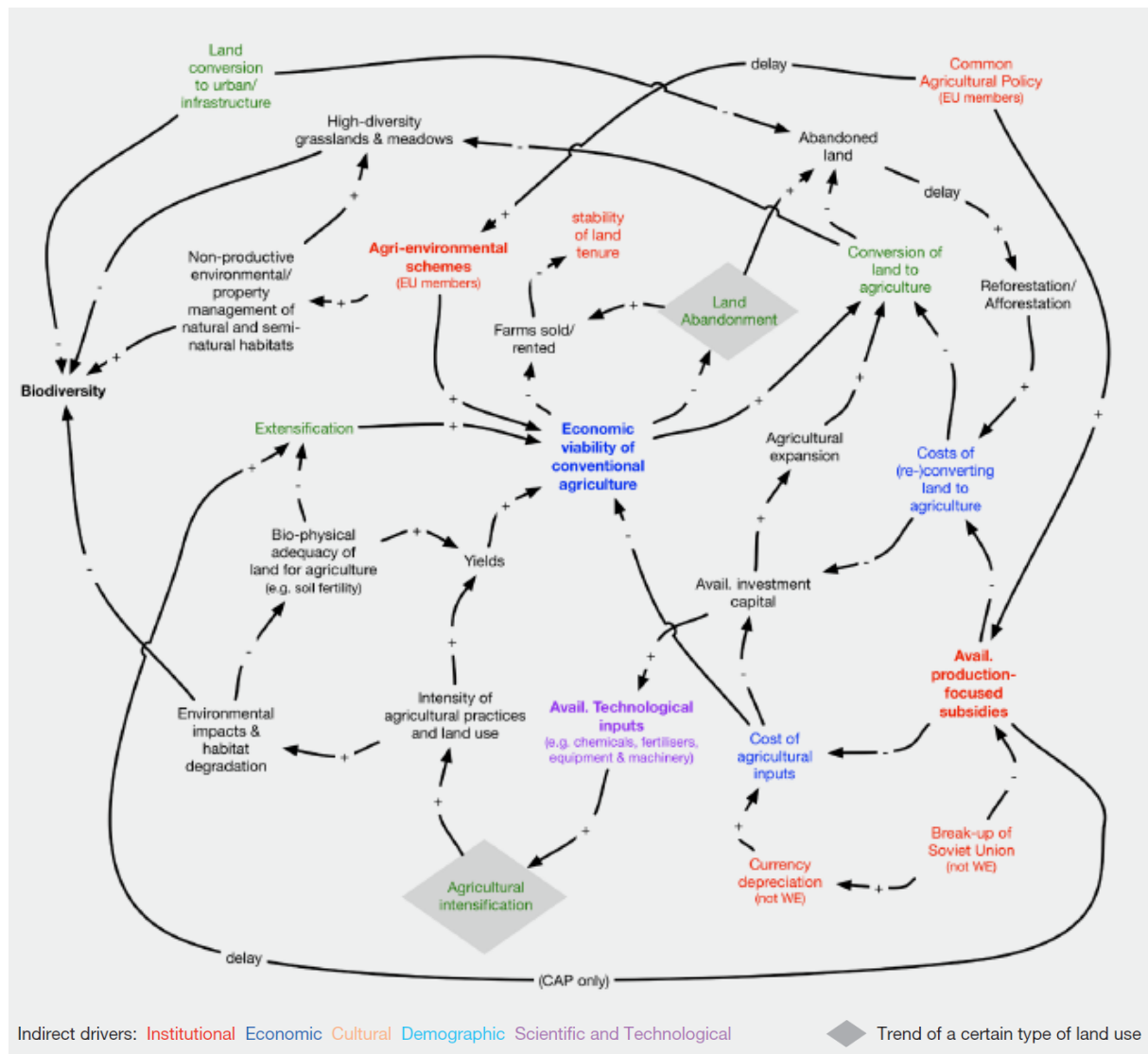


Figure 4.12: The availability, or unavailability, of agricultural subsidies has been a major driver of agricultural land-use change in Europe and Central Asia (own illustration). Production-based subsidies have generally led to the intensification of farming. The sudden unavailability of subsidies in large parts of the region following the dissolution of the Soviet Union was a major driver of agricultural land abandonment, as well as intensification on the most fertile soils. The introduction of non-production-based subsidies, for example agri-environmental schemes in the European Union, has improved the ability of small-scale farmers to maintain lower-intensity agricultural practices with long-term benefits for biodiversity.

In Eastern Europe and Central Asia, the political changes since the 1990s were accompanied by radical large-scale land reforms, involving the elimination of the state monopoly and division of land ownership (state, collective, and private) (Lerman et al., 2004; W. M. Liefert & Liefert, 2012; Liira et al., 2008; Rozelle & Swinnen, 2004; I. E. Smelansky, 2003; Swinnen, Burkitbayeva, Schierhorn, Prishchepov, & Müller, 2017) (Figure 4.12). Since then, the areas of large private agricultural companies owned by agro-holdings and their role in the agricultural sector has constantly expanded (BEFL, 2016; Nefedova, 2016; Petrick et al., 2013; O. Visser et al., 2012, 2014), especially in the most favourable regions for agriculture, (e.g., south-western Russia, south-eastern Ukraine, and Kazakhstan). However, subsistence farming has played the main role in the food security of citizens in villages, towns and cities. For example, in Russia, the economic crisis in 2008 led to a 2-fold increase in the number of rural

residents engaged in subsistence farming, and in the cities the number increased by 2.8 times. Subsistence farms produced 98% of potatoes, vegetables and fruit crops, 82% of milk, 68% of meat and 54% of eggs (Martyn & Yevsiukov, 2009; Swinnen et al., 2017). Appropriate legislation is important for biodiversity conservation on agricultural lands. However, currently for the majority of Eastern European countries there is a lack of links between environmental legislation and legislation related to land, territorial development and agriculture (I. E. Smelansky, 2003).. For example, Russian legislation does not identify grasslands as a separate category of agricultural land. Several legal regulations address pastures (grazing lands) and hay-making lands (Bakirova, 2011; I. E. Smelansky, 2003; I. Smelansky & Tishkov, 2012); the federal law provides some legal framework for constraining grassland transformation into other land uses but it has been insufficient to protect grasslands outside protected areas.

Land ownership is another institutional driver that has changed across Europe and Central Asia from having many small landowners in the agricultural sector to increasingly larger areas of land being managed by fewer farmers – either after being purchased by farmers or based on an increase in rented land. For the latter, concern is raised that managers' connection with, and sense of responsibility to the land is decreasing, especially in the case of short term rental agreements. This may result in poor management, including less environmental considerations (Forbord, Bjørkhaug, & Burton, 2014; Lobley & Potter, 2004; Stokstad, 2010). This problem is especially vital in some countries of Central Europe (e.g. in the Czech Republic) where the original small owners sold or leased their land to new owners from elsewhere after restitution in the 1990s (Skokanová et al., 2016).

4.5.2.2.2 Economic drivers of trends in agricultural land use

Economic factors often underpin decisions about cultivation or termination of agricultural production (**Figure 4.12**). Agricultural expansion and intensification on fertile, productive land often coincides with land abandonment on marginal land (Beilin et al., 2014; Skokanová et al., 2016). These two trends are largely driven by global trade of the agricultural market since the 1950s (van Vliet et al., 2015). As a result of global trade, the size of farms and their specialization have increased (Lobley & Butler, 2010).

In Eastern Europe and Central Asia, economic factors include prices for agricultural products (outputs), and the parity of the prices between inputs and outputs. This was most likely one of the primary reasons for widespread termination of farming and livestock production in these subregions (Rozelle & Swinnen, 2004; Schierhorn et al., 2016) (**Figure 4.13**). In some countries of Eastern Europe and Central Asia, an inability to fill budget gaps led governments to reduce subsidies for agricultural production and consumption by 95% (Prishchepov et al., 2013). The agricultural sector, and particularly livestock sector, immediately faced a mismatch between increased prices for inputs and output production (Sedik, 1993). Additionally, the removal of subsidies led to domestically produced beef and milk becoming non-competitive compared to subsidized imported goods (Schierhorn et al., 2016). Lack of cash flow to cover production costs led to a reduction in livestock numbers and concomitant reduction in fodder crop production (Prishchepov et al., 2017; Rozelle & Swinnen, n.d.; Schierhorn et al., 2013; Sedik, 1993) which resulted in widespread agricultural land abandonment (Ioffe, Nefedova, & Zaslavsky, 2004; Liefert & Liefert, 2012; Prishchepov, Radeloff, Baumann, Kuemmerle, & Müller, 2012; Schierhorn et al., 2013). The wheat production sector was also affected, but to a lesser extent than other grain and fodder crops. Maize, sunflower and beets continued to be cultivated at almost the same levels as in 1990. Availability of the domestic market and accessibility to international markets, distances to the markets and transportation costs may have determined the decision to abandon or re-cultivate agricultural land (A. V. Prishchepov et al., 2013). For instance, discovery of new markets for Russia's wheat most likely stimulated partial re-cultivation in the Russian south, in

proximity to water ways and sea ports (FAO, 2009). Similarly, growing demand in the Chinese market triggered re-cultivation of abandoned lands for soya production in the Amur region of Russia (Rosstat, 2016). The economic advantages or disadvantages of the agricultural sector compared to other sectors, may drive the decision to quit farming or to pursue alternative income sources. For instance, the value added by agriculture to total GDP declined by 32% from 1990 to 2000 (Prishchepov et al., 2017). Additionally, low taxation, which was based on normative average yields during the Soviet era, did not stimulate either the cultivation of lands, or a concentration on yield increases. Land transaction costs and legal burdens themselves preclude fast transactions and limit incentives for the re-cultivation of abandoned land (Meshkov, 2014; Uzun, 2011).

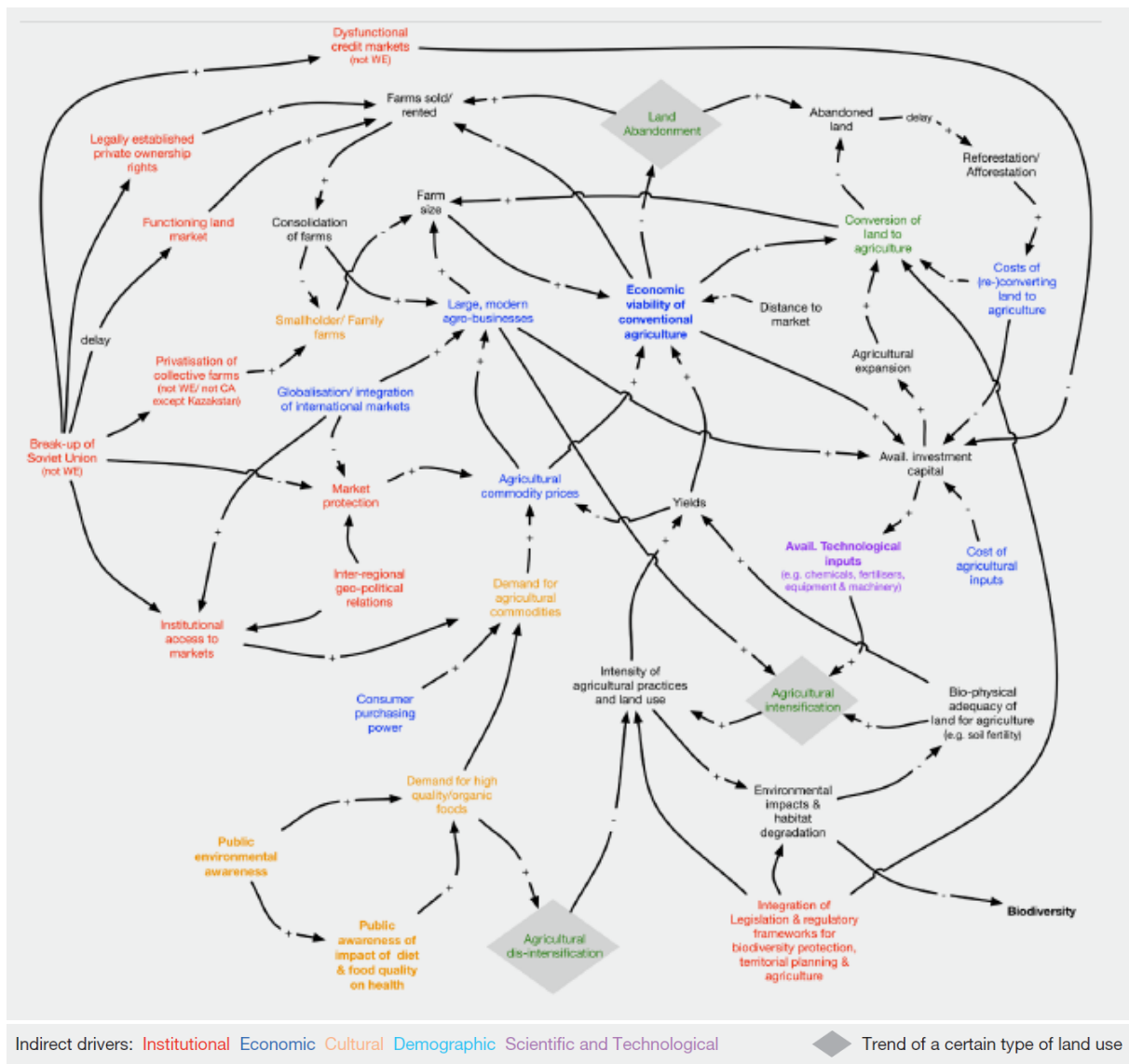


Figure 4.13: Land, credit and commodity markets have had important impacts on the economic viability of conventional agriculture across Europe and Central Asia, and as such have been key factors in regional intensification and abandonment trends (own illustration). The dissolution of the Soviet Union was a source of considerable institutional turmoil affecting the function of these markets in many countries in the region. The recent trend towards agricultural de-intensification in some parts of Europe and Central Asia is largely driven by growing public environmental and health awareness.

19046 4.5.2.2.3 Cultural drivers of trends in agricultural land use

19047 Socio-cultural attributes of individual farmers have had a bearing on the extent of land-use
 19048 intensification or change, thereby slowing down the effects of specialization and global trade (Lobley
 19049 & Butler, 2010). “Property management” or property-related issues play a vital role in the farmer’s
 19050 practice; and values related to family and individual strategies may often explain why landowners
 19051 undertake land-use changes that are not profitable (Kristensen, 2016) (**Figure 4.14**).

19052 In Western Europe, farm and farmer characteristics have been particularly important drivers of
 19053 specialization (Breen, Hennessy, & Thorne, 2005; Gorton, Douarin, Davidova, & Latruffe, 2008; van
 19054 Vliet et al., 2015). Choices of crops and farming systems are largely controlled by economic and legal
 19055 factors (markets and state subsidies/regulation); however, local traditions may still moderate the rate
 19056 of change (Beilin et al., 2014; Curado et al., 2011; Elmhagen, Kindberg, Hellström, & Angerbjörn, 2015;
 19057 Forbord et al., 2014) (**Figure 4.14**). Ethical and cultural trends have gradually brought changes in diet
 19058 and food consumption as well as leisure activities. There is a growing number of consumers who are
 19059 particularly interested in how and where food was produced and, sometimes, in participating in the
 19060 production process (Guarino et al., 2015). Additionally, there is also a growing interest in leisure
 19061 farming and hobbyhorses. Quality products, related to high natural value farmlands and often linked
 19062 to community-led local development policies, and in 2010 reached a substantial weight, worth about
 19063 18% (excluding wine) of the gross saleable production in the European Union agricultural sector
 19064 (http://ec.europa.eu/agriculture/quality/schemes/index_en.htm). At the same time, in Western and
 19065 Central Europe, organic products comprise about 1% of total food sales, but trends are increasing (FiBL,
 19066 2015).

19067 In Central Europe since the 1990s many livestock farms have collapsed due to termination of subsidies
 19068 for external inputs (e.g. fertilizers) for fodder production during the socialist period. This resulted in
 19069 the large-scale movement of people with agricultural experience into cities or abroad (Bell & Muhidin,
 19070 2009), leading to widespread abandonment of farmland (Munteanu et al., 2014; van Vliet et al., 2015).

19071 In Eastern Europe and Central Asia during the Soviet era, agricultural enterprises fulfilled many
 19072 obligations related to providing jobs and services to local population (e.g., schools, shops, centres of
 19073 culture, libraries etc.) (**Figure 4.14**). Since the 1990s these obligations have been transferred to local
 19074 governments, which have not had resources to fulfil them (G. Ioffe, Nefedova, & De Beurs, 2012). This
 19075 led to a sharp increase in the burden on the biological resources of rural areas (e.g. through poaching
 19076 and illegal logging); destructive extraction of soil and mineral resources (e.g. through sale of fertile
 19077 topsoil and illegal mass extraction of building materials and coal); as well as growing poverty in rural
 19078 areas (Allina-Pisano, 2007; Ovcharova & Pishnyak, 2003; Petrick et al., 2013; O. Visser & Schoenmaker,
 19079 2011). Since the 1990s a large proportion of agricultural land has been freely transferred to multiple
 19080 private owners who had a share in the property of former collective farms. This has led to the
 19081 appearance of a significant number of non-agricultural enterprises (Lerman & Shagaida, 2007; Petrick
 19082 et al., 2013; Shagaida, 2005) operated by managers often with a lack of adequate professional
 19083 knowledge in agriculture (Babmindra, 2006; Maslak, 2015; Sabluk, Hajduts’kyj, & Danylenko, 2015).
 19084 For example, in Ukraine land reform has led to the privatization of 12’000 collective or state farms;
 19085 and the majority of the agricultural land (27 million ha, 66% of all agricultural land of the country) was
 19086 distributed among 6.9 million citizens (<http://land.gov.ua>, (Khodakivs’ka, 2015). This has created a
 19087 precondition for widespread land abandonment.

19088 In general, quantitative studies confirm that agricultural land abandonment is strongly linked to a
 19089 decrease in rural population density, ageing population, and lower birth rates (Ioffe et al., 2004;
 19090 Meyfroidt et al., 2016; Prishchepov et al., 2017). Demography legacies also played a crucial role in
 19091 explaining the patterns of land abandonment, such as reduced population due to World War II in

western Russia (e.g., Smolensk province), and outmigration in the 1960s and 1970s from the non-Chernozem region (Ioffe, 2005; Prishchepov et al., 2013). It has been proposed that agricultural production loses its economic feasibility when rural population density falls below five people/km² (G. Ioffe et al., 2004). The regions with higher birth rates and higher population density were found to be more favourable for re-cultivation (Meyfroidt et al., 2016; Shagaida, 2005).

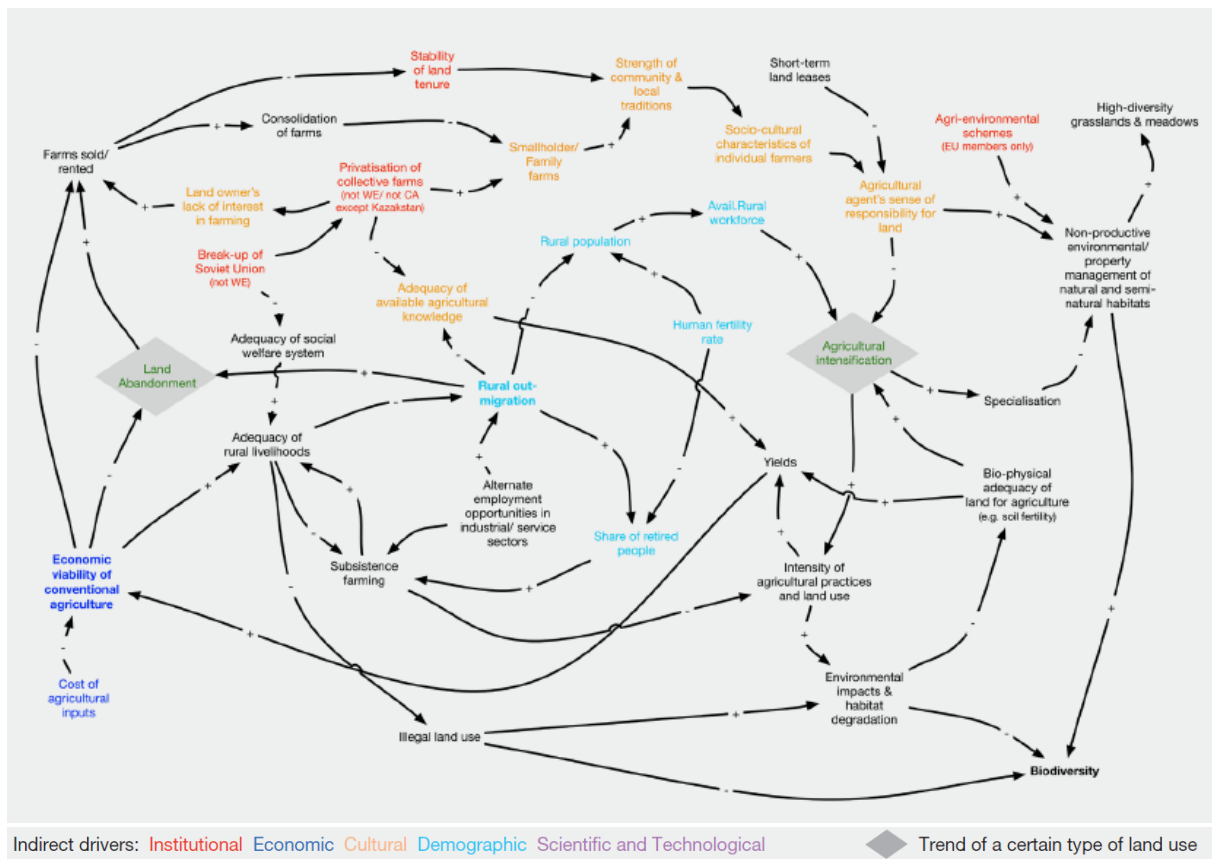


Figure 4.14: Agricultural intensification and abandonment trends in Europe and Central Asia are also influenced by socio-cultural and demographic factors (own illustration). Whilst the consolidation of farms has led to some improvements in economic viability, it is also linked to the erosion of local traditions and of a sense of long-term custodial responsibility for the land, which are important for the continuation of non-productive management practices for biodiversity. Rural outmigration is also linked to the loss of key forms of agricultural knowledge.

4.5.2.2.4 Technological drivers of trends in agricultural land use

Technological drivers such as biotechnology and mechanization (e.g. tractors) are important drivers of change in the agricultural sector (Jepsen et al., 2015). Better production technology, for instance application of high power tractors and other machinery, may encourage farmers to cultivate more land, thus stimulating re-cultivation of abandoned plots. However, improvement of technological production can also be strongly influenced by whether economic factors favour investment in technological advances (Jepsen et al., 2015).

4.5.3 Trends and indirect drivers of changes in forestry

4.5.3.1 Trends in forestry

Forest management systems vary across Europe and Central Asia. In the boreal zone forest management with clear-cuts followed by intensive silviculture dominates in Fennoscandia (Granhus, Eriksen, & Moum, 2015), and wood mining without silviculture in boreal Russia (Naumov, Angelstam, & Elbakidze, 2016) (**Figure 4.15** and **Figure 4.16**). Forestry in the temperate zone utilizes a wider spectrum of management systems. This includes different harvest and regeneration systems ranging from clear-cut management with tree plantations to continuous cover forestry with single-tree harvest and natural regeneration (Timo Kuuluvainen, Tahvonen, & Aakala, 2012; Pommerening & Murphy, 2004). Almost all forest management systems result in simplified forests with loss of structural complexity and biodiversity at multiple spatial scales. In the Mediterranean, agroforestry systems are widespread, which incorporate combinations of trees, grasslands and rotation cereal cropping. In Western, Central and Eastern Europe, traditional agroforestry systems have been key elements in the European cultural landscapes throughout history (Eichhorn et al., 2006; Erixon, 1960) (**Figure 4.17**). As an example, the Spanish dehesas and Portuguese montados form extensive agro-silvo-pastural savannahs, which cover about 5 million ha in south-western Spain and Portugal (Joffre, Vacher, de los Llanos, & Long, 1988; Tobias Plieninger, Pulido, & Konold, 2003).



Figure 4.15: Even-aged (left) Scots pine (*Pinus sylvestris*) and (right) Norway spruce (*Picea abies*) forests with simplified vertical and horizontal structures are the outcomes of forest management systems aiming at maximum sustained yield with even-aged silvicultural system (Bergslagen region, Sweden) (Photo – Per Angelstam). Generally, forest management is based on silviculture using the gradient between even-aged and uneven-aged systems. There are three general types of age-class structures that are managed for: (1) even-aged systems that include clear-cutting or seed tree systems; (2) the intermediate double-cohort systems with shelterwood cutting, and (3) uneven-aged systems with single tree and group selection. The different systems can be understood better if considered as located in a continuum of proportion trees removed at each treatment and the size of the treatment unit.



Figure 4.16: Remaining intact forest landscapes (in the photo above – intact forests in the Komi Republic, Russian Federation, photo – Marine Elbakidze) in Western, Central and Eastern Europe are a subject to on-going wood mining. Initially single high value trees, and later entire stands in naturally dynamic forests are harvested without plans for future forest development. This leads to frontiers of wood felling that develop as market demands spread into increasingly remote regions. In Fennoscandia, this process began about 150 years ago and in remote parts of north-western Russia it began in the 1960s (Naumov et al., 2016), and is still on-going (Potapov et al., 2017).



Figure 4.17: Dehesa and montado agroforestry systems integrate use of forest, grasslands, and fields (Pardo & Gil, 2005) (in the photo above - montado system in Portugal, photo – Marine Elbakidze). These cultural landscapes host outstanding biodiversity (Bugalho, Caldeira, Pereira, Aronson, & Pausas, 2011; Diaz, Tietje, & Barret, 2013) and provide multiple contributions to people that enhance quality of life. The importance of traditional agroforestry landscapes has been recognized at the European Union level and the relevance of traditional practices to deliver multiple contributions of nature to people has been acknowledged (Bergmeier et al., 2010; Eichhorn et al., 2006; Marañón, 1988; Rackham, 2003). However, at present these landscapes are deteriorating due to farmland abandonment, intensification of agriculture or creation of forest plantations (Garrido et al., 2017).

19160 The main trends in forestry across Europe and Central Asia are as follows: (1) increasing intensity of
 19161 management on forested land; (2) continued logging of intact forests; (3) rehabilitation of forest land
 19162 after overgrazing, overexploitation, and desertification; and (4) efforts to implement sustainable forest
 19163 management. These trends are assessed in more detail below.

19164 Trend 1: Increasing intensity of management on forested land

19165 Increasing intensity of management of forested land includes: (i) increasing extraction of bioenergy
 19166 resources; (ii) increasing area of plantations; and (iii) intensification of forest management. Production
 19167 of forest biomass for energy purposes includes increasing use of more intensive management methods
 19168 and extraction of a larger fraction of biomass during harvest operations, including tree-tops, branches
 19169 and roots (Bouget, Lassauce, & Jonsell, 2012). It is theoretically possible to increase the availability of
 19170 forest biomass significantly beyond the current level of resource utilization (Verkerk, Anttila, Eggers,
 19171 Lindner, & Asikainen, 2011). Intensification of biomass removals from forests has raised concerns
 19172 about its environmental impacts on forest productivity, biodiversity, soil quality, and climate change
 19173 mitigation potential, as well as social values (Aherne, Posch, Forsius, Lehtonen, & Härkönen, 2012;
 19174 Bouget et al., 2012; Forsius et al., 2016; Triviño et al., 2015). The trade-offs between increasing biomass
 19175 output and delivery of diverse contributions of nature to people are recognized as a major challenge
 19176 for forestry in Europe and Central Asia (Verkerk et al., 2011). These concerns have resulted in the
 19177 development of sustainability criteria for bioenergy production (European Commission, 2009).
 19178 However, several studies have pointed to the need to include landscape-scale segregated approaches
 19179 to define appropriate indicators for long-term sustainability, including energy wood production (Fu,
 19180 Wang, Su, & Forsius, 2013; E. Nelson et al., 2009; Vihervaara et al., 2015). This applies in particular to
 19181 resolving potential impact on biodiversity, soil carbon, nutrient store and leaching (Forsius et al., 2016),
 19182 but also to forests as an asset for recreation and nature-based tourism.

19183 Plantation forestry in Europe constituted 9% of the forested area in 2015 with an increase during the
 19184 last 20 years of 3.8 million hectares (Forest Europe, 2015). The fraction of plantation forests varies
 19185 among countries in Western Europe and Central Europe (**Figure 4.18**).

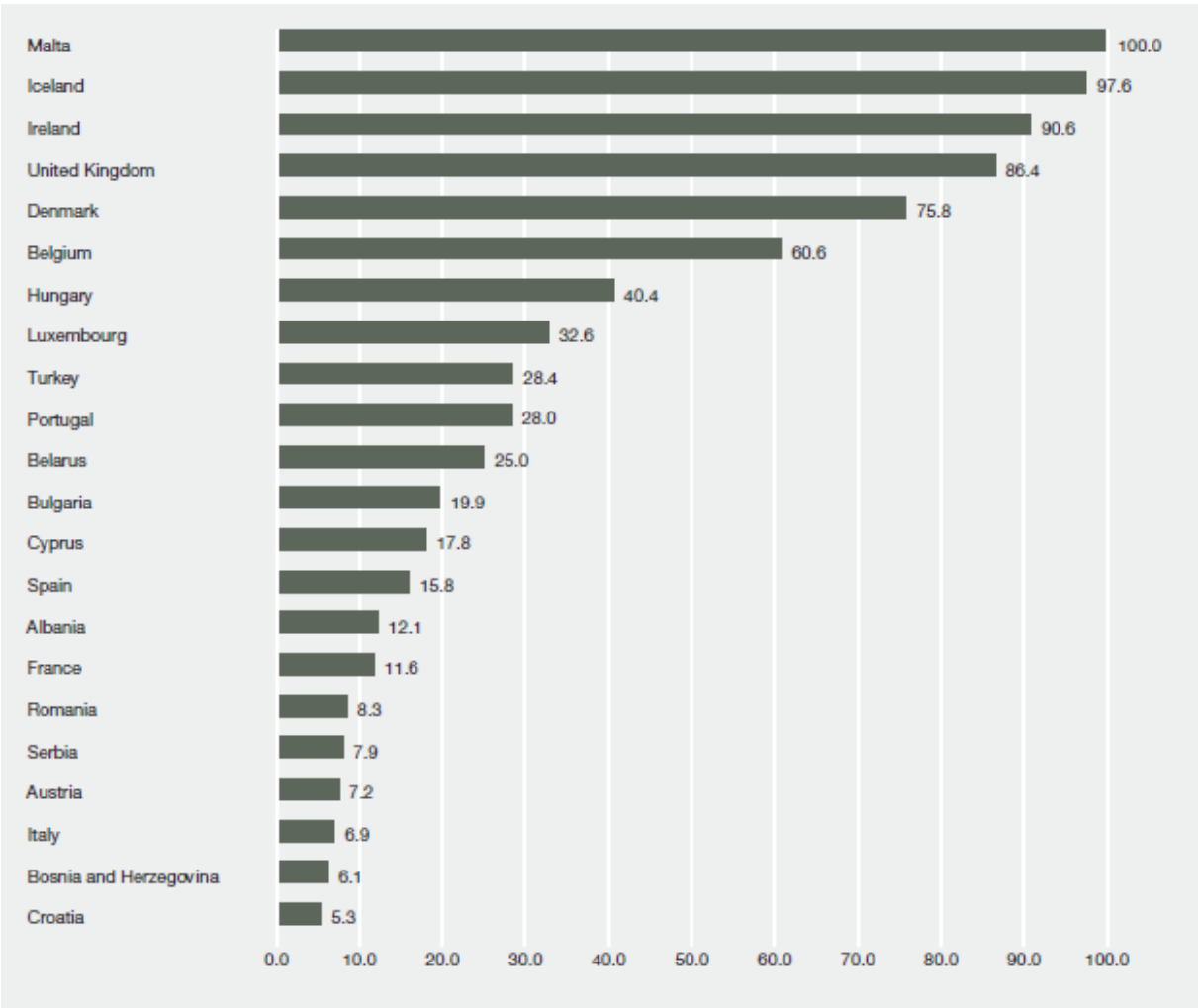


Figure 4.18: Western, Central and Eastern European countries with a share of over 5 per cent of plantations of the total forest area (Forest Europe, 2015).

The growing stock of forests in continental Europe has increased at an annual average of 1.4% or, in absolute terms, by 403 million cubic meters per year over the last 25 years (Forest Europe, 2015). Growing stock has increased despite a significant increase in annual felling. During the period 1990 – 2010, annual felling increased by more than 20% (from 216 to 263 million cubic meters) in Europe. Thus, only over half of the growth is harvested. Additionally, there are combined effects of increased CO₂ concentration and nitrogen deposition. Sweden and Finland are viewed as role models for the development of maximum sustained yield wood production in Europe (e.g. Elbakidze, Andersson, et al., 2013; Lindahl & Westholm, 2010). However, there are arguments that sustained yield forestry as a single-use management (Behan, 1990) focused on wood, changes forest composition and structure, and alters the natural dynamics in forest landscapes (Bawa & Seidler, 1998; Holling & Meffe, 1996; Luckert & Williamson, 2005). As a consequence, forest ecosystems lose native species, habitats, and ecological processes, which affect ecological integrity and resilience (Farrell et al., 2000). The Russian Federation currently aims to increase the sustained yield of wood by intensifying wood production in accessible areas previously harvested by wood mining, (Naumov, Angelstam, & Elbakidze, 2017). This requires changes in forest management that include silvicultural methods, for example, scarification, planting or seeding, pre-commercial thinning and even fertilization (Elbakidze, Andersson, et al., 2013).

Trend 2: Continuous logging of intact forest landscapes

Industrial forestry has expanded throughout Europe over the centuries, basically from south-west to north-east (Lotz, 2015; Lundmark, Josefsson, & Östlund, 2013). According to Potapov et al (2017), industrial timber extraction, resulting in forest landscape alteration and fragmentation, was the primary global cause of intact forest landscape area reduction. Three countries comprise 52% of the total reduction of intact forest landscapes area: Russia (179 000 km² of IFL area lost), Brazil (157,000 km²), and Canada (142,000 km²). In Europe and Central Asia clear-cutting was the main intact forest landscape loss cause in the temperate and southern boreal zones (54%). Proportional to the year 2000 IFL area, the highest percentages of intact forest landscape area reduction were found in Romania (Central Europe), which lost all of its intact forest landscapes. Russia has approximately 20% of the world's forests, and human influence on forests has been growing over recent decades, mainly as a consequence of logging activities including both clear-felling and selective logging (Achard et al., 2006; Naumov et al., 2017). Easily accessible Russian forest resources are being exhausted (e.g., Naumov et al., 2016). Despite a huge forested area there is a serious shortage of accessible wood resources demanded by the forest industry. Large sawmills, pulp and paper enterprises, especially those focused on output with low added value, are heavily reliant on low transportation costs for the delivery of raw materials from the forest. Thus, increasingly, forest logging companies harvest in protective forests and other valuable forests (Naumov et al., 2017) that support biodiversity conservation and rural development.

Trend 3: Rehabilitation of forest land after overgrazing, overexploitation, and desertification

This trend is prominent in Central Asia, where forest cover is about 5% of the subregion. Distribution of forested areas is uneven with the largest forested areas in Turkmenistan and the smallest in Tajikistan. Due to overall arid environments, the wood production in this subregion is low, and its economic/monetary contribution is insignificant (Kleine et al., 2009). However, forests deliver diverse contributions to people, including water regulation, soil protection, climate mitigation, fire wood, and recreational value at multiple scales. Nevertheless, significant degradation of forests has taken place since World War II, while not necessarily decreasing forested area. Main causes include converting forested area into agricultural land, overgrazing and overexploitation, including illegal logging, and fires (Байзаков, 2014; Токторалиев & Аптокуров, 2009). Major concerns are related to the disappearing Aral Sea, leaving a large area of degraded land. Attempts to afforest this area are being made to increase the area of land defined as forests in Kazakhstan. The forest management in this subregion is mainly focusing on rehabilitation of degraded forested land. This includes reforestation and afforestation as well as planting trees and shrubs to combat desertification (Meshkov, 2014).

Trend 4: Multifunctional forestry

For the past four centuries sustained yield forestry has been focused mainly on wood for construction, fibre, or fuel. However, the normative interpretation of sustainability in forestry became broader when sustainable forest management policies appeared at the end of the twentieth century (MCPFE, 1998, 2001; S. Wang & Wilson, 2007). Sustainable forest management aims at maintaining, now and in the future, sustainable ecological, economic, social, and cultural functions of managed forests through multi-stakeholder participatory approaches (W. A. Hahn & Knoke, 2010; MCPFE, 1998, 2001; Wiersum, 1995). This requires that forest managers consider the use of a broad range of nature's contributions to people through adaptive management and governance to be able to handle potentially conflicting demands at multiple spatial scales (Bawa & Seidler, 1998; Behan, 1990; Bouthillier, 2001; Farrell et al., 2000; W. A. Hahn & Knoke, 2010; C. Sandström, Lindkvist, Öhman, & Nordström, 2011; Wiersum, 1995). Lindahl et al. (2017) noted that this pathway is influenced by ideas of ecological modernization and the optimistic view that existing resources can be increased, thus prioritizing the economic dimension of sustainability. At present, society's interest in sustainable forest management is growing.

This is mainly linked to bioenergy production and energy security as well as climate change adaptation and mitigation (Spittlehouse & Stewart, 2003). There are arguments that timber supply-oriented sustained yield concept is no longer appropriate (Wiersum, 1995), and forest managers need to “develop from being crop managers to ecosystem managers” (Farrell et al., 2000).

Countries in Europe and Central Asia have diverse natural, historical, societal, and economical legacies and thus have different starting points in their trajectories of development toward sustainable forest management (P. Angelstam et al., 2011; Lehtinen, Donner-Amnell, & Sæther, 2004). For example, recent analyses of the future development of boreal forests in Western Europe (Claesson, Duvemo, Lundström, & Wikberg, 2015) indicate that this process will divide forest landscapes into intensively managed stands with harvest return intervals of 60-80 years and only scattered remnants of old growth forests set aside for biodiversity conservation purposes (**Figure 4.19**). To counteract this segregated trend there is an increasing focus on integrative approaches in forest management (Kraus & Krumm, 2013). These initiatives include green tree retention, identification of small valuable forest habitats, and promotion of mixed forest stands (e.g. Brang et al., 2014; T. Johansson, Hjältén, de Jong, & von Stedingk, 2013). Similarly, integrative approaches may benefit the protection of wooded grasslands - habitats that have declined dramatically during the 20th century (R. Axelsson, Angelstam, & Svensson, 2007) – with their ecological and social values (T. Hartel & Plieninger, 2014).

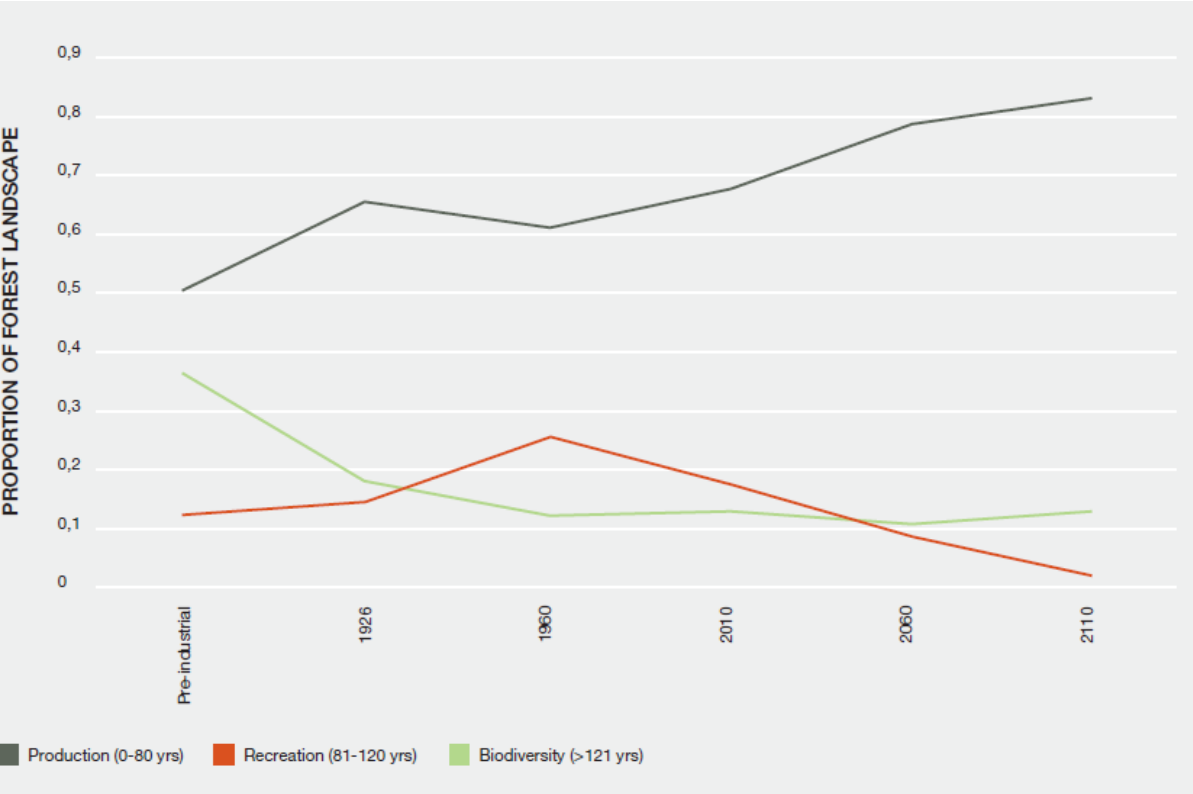


Figure 4.19: Past, current and projected proportions of three forest stand age classes in Sweden representing maximum sustained yield wood production (0-80 yrs), recreation (81-120 yrs) and biodiversity conservation (>121 yrs); pre-industrial data from Angelstam and Kuuluvainen (2004), and other periods from Claesson et al. (2015). Note, however, that for biodiversity conservation these statistics overestimate the functionality of areas >121 yrs as functional habitat networks. Three reasons are loss of the ecologically most important forest, say >180 yrs with dead wood in different decay stages, small patch sizes and limited functional connectivity.

4.5.3.2 Drivers of trends in forestry

The overview model (Figure 4.20) shows the dynamic inter-relationships within and between indirect and direct drivers of change in forestry identified via the literature review process. This overview model is then further unpacked at a variety of levels of detail to examine the major dynamics of indirect drivers of changes in forestry.

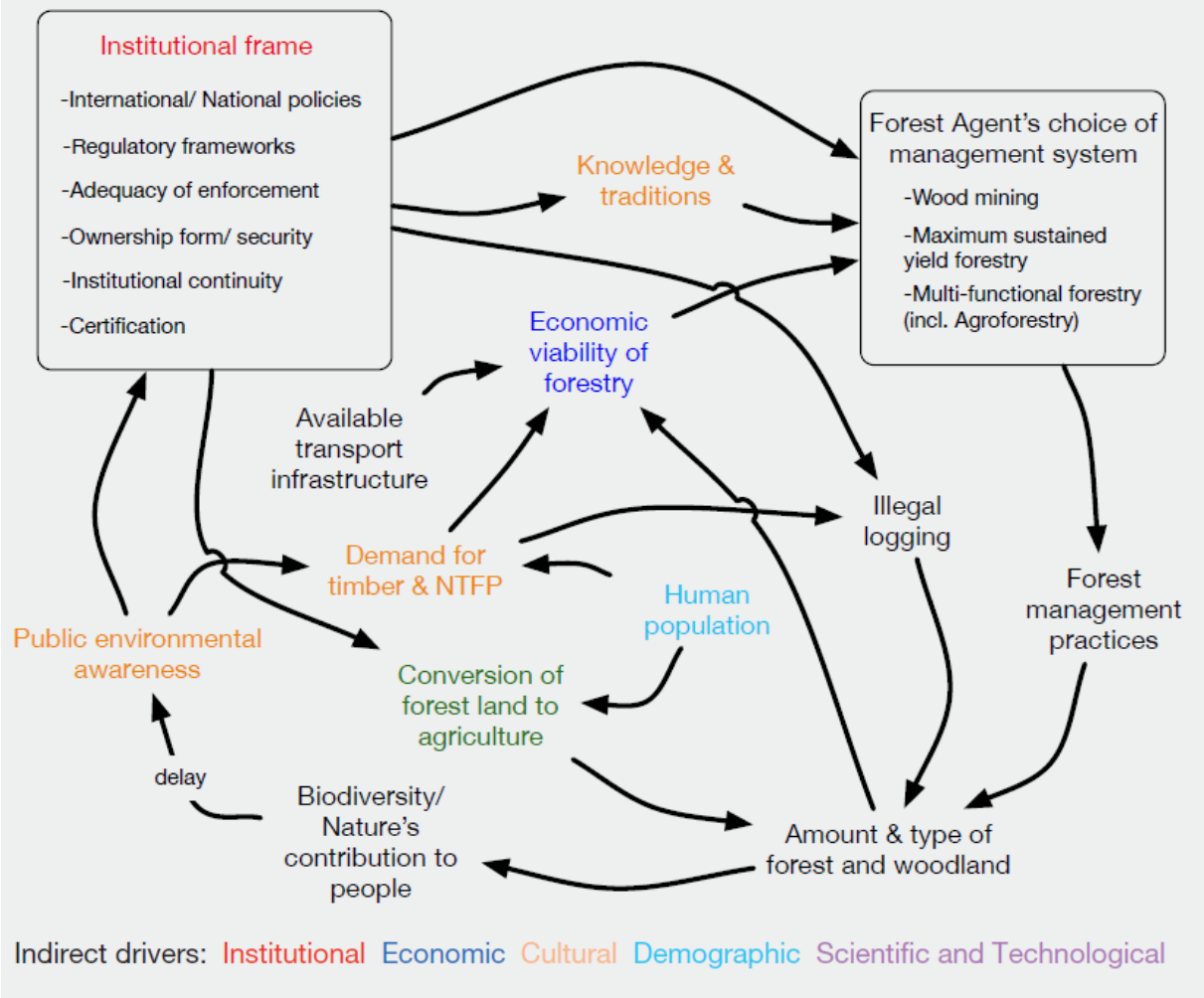


Figure 4.20: An overview of the key drivers and systemic interconnections leading to changes in forestry in Europe and Central Asia (own illustration). Given the long lag times for forest regeneration, past choices of forest management systems continue to exert a major influence on the amount and types of forest and woodland available in Europe and Central Asia. The choice of forest management system is influenced by a broad set of institutional drivers, the availability of relevant knowledge, regional forestry traditions, and considerations of economic viability. Multi-functional forestry, for example, is dependent on extant demand for non-timber forest products, such as wild foods, or for social values, such as recreation and tourism. Illegal logging and the conversion of forested land to agricultural land are also important drivers in parts of Europe and Central Asia. These inter-relationships are further unpacked in the following sections.

4.5.3.2.1 Legal frameworks

Regulatory frameworks for forest management have a long history in Europe and Central Asia. In Western Europe, they date back to at least the 17th century. Starting already in the beginning of the 19th century, forest management for wood production was regularly taught at forestry schools aiming

19300 for efficient silviculture. After two centuries of maximum sustained forestry yield, in recent decades
 19301 the international policy pendulum (e.g. CBD, 2010b; European Commission, 2013; MCPFE, 1998, 2001)
 19302 has swung towards multiple use and benefits. Initially, this was focused on biodiversity conservation
 19303 and later also on rural development (Kennedy, Thomas, & Glueck, 2001).

19304 The Montréal Process developed sustainable forest management principles for the temperate and
 19305 boreal forests; and the Ministerial Conference on Protection of Forest in Europe (Pan-European
 19306 process or Forests of Europe) for countries in Western, Central and Eastern Europe (Forest Europe,
 19307 2011). The Pan-European criteria and indicators provide guidelines for sustainable forest management
 19308 at the national and sub-national levels, and to operationalize and complement the existing (MCPFE,
 19309 1998, 2013). There is a common strategy for 46 countries in Western, Central and Eastern Europe on
 19310 how to sustainably manage their forests (Forest Europe, 2015). The sustainable forest management
 19311 concept is an overarching guiding principle at the policy level. However, there is considerable variation
 19312 in how this concept is implemented among countries (Lehtinen et al., 2004), different forest owner
 19313 categories, and over time in a given country. In 2011, Forests Europe presented “European forests
 19314 2020 Goals and Targets” (Forest Europe, 2011) that requires the sustainable management of all
 19315 European forests, including multiple forest functions and enhanced use of forest goods and services
 19316 **(Figure 4.21).**

19317 Regarding agroforestry systems, the agricultural subsidy regime within the European Union is
 19318 considered unfavourable towards silvo-arable practices (e.g. Fragoso, Marques, Lucas, Martins, &
 19319 Jorge, 2011; T. Plieninger, Modolell y Mainou, & Konold, 2004); and there is a need to reinforce and
 19320 promote alternative agricultural and non-agricultural economic activities in rural areas. New functions
 19321 include leisure and recreation (García Pérez, 2002; Pinto-Correia, 2000; Surová & Pinto-Correia, 2009).
 19322 Indeed, Gaspar et al. (2009) showed that mixed livestock dehesa farms made optimal use of resources,
 19323 and had little dependence on external subsidies. Given uncertainties about the European Union
 19324 subsidies, this type of farm might be a goal for dehesa farmers. Thus, the maintenance of the
 19325 traditional agroforestry systems in Spain and Portugal is a good example of how a diversity of forest
 19326 and woodland management regimes sustains multiple goods, services and landscape values (Linares,
 19327 2007). However, Pinto-Correia (2000) and Plieninger et al. (2004) pointed out that this requires a
 19328 holistic landscape approach including conservation-incentive schemes, environmental education, and
 19329 technical assistance.

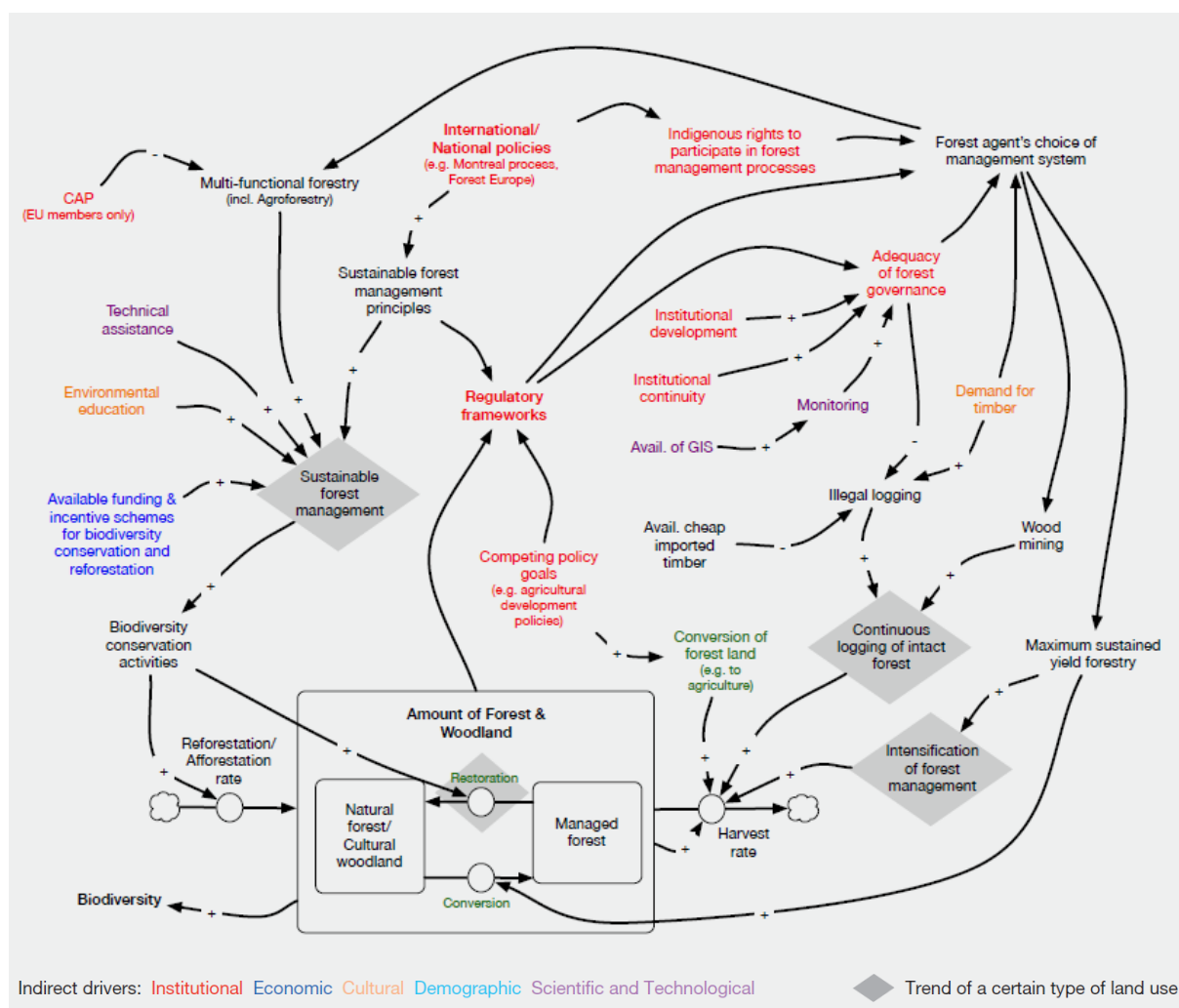


Figure 4.21: Legal frameworks are key drivers of change in forestry in Europe and Central Asia (own illustration). A number of recent international processes have led to the evolution and adoption of a set of principles supporting sustainable forest management, and strengthening regulatory frameworks, which govern norms and practices associated with other forms of forest management. However, these new institutions require further integration to reduce conflicts with other policies and institutional legacies.

In Central Asia at the beginning of the 1990s, national agricultural policies such as converting forests into arable land and pasture continued to reduce forested areas. For instance, in Uzbekistan the area of tugay forests – a form of riparian forest or woodland associated with fluvial and floodplain areas in arid climates – decreased to less than one-tenth of the original area. Walnut forests in Kyrgyzstan decreased by 50% while mountain slope desertification increased by 31% (Токторалиев & Аттокуров, 2009). Since the 1990s, forest management organizations at different levels have gone through many reforms (Байзаков, 2014) and political and economic uncertainties, and severely weakened forest governance had caused growth of illegal logging and forest fires. The stabilization of economies in the region has shifted the attention to the forest crisis in the region. For example, Kazakhstan has prohibited cutting of saxaul forests, and Kyrgyzstan has announced a moratorium on cutting of walnut forest. The import of wood from Russia was renewed, and the pressure on forests has declined. Institutional development strengthened forest protection in the region. Also, introduction of GIS technologies enabled forestry to collect and monitor the forest data more effectively (Anon, 2007, 2008).

illustration). Environmental NGOs have played a key role in the adoption of forest certification schemes, which have reduced “wood mining” of remaining intact forests and have led to the inclusion of biodiversity conservation criteria and indicators in forest management systems. The establishment of functioning markets for non-timber forest products is important to grow demand for multi-functional forests, which promote forest biodiversity.

4.5.3.2.3 Markets of non-timber products

Emergence of new export markets for non-timber products, primarily medical plants and walnuts, has increased reliance of local populations on forests. The evidence shows that the health of forest ecosystems that produce these products greatly improves the quality of life of local households (Fisher, Schmidt, Steenhof, & Akenshaev, 2004).

4.5.3.2.4 Forest ownership

The forest harvest rate, land conversion and management system is decided by the choices of forest managers – individual managers and land owners – but a wide range of drivers influence their decisions in an interrelated and complex way. These drivers are depicted in **Figure 4.23** summarizing the causal links influencing forest ecosystems. The choice of management system is influenced primarily by cultural legacies (managers’ world views of forestry), laws and policies (institutional drivers), the demand for specific forest products (e.g. increasing use of biofuels) as well as by costs, e.g. related to development of infrastructure. For example, the opportunity for introducing intensified forest management in Eastern Europe based on pre-commercial and commercial thinning is hampered by short forest leasing periods (Naumov et al., 2017). A permanent transport infrastructure, which is available not only for harvesting, but for silviculture is also necessary. To pay for these costs, commercial thinning usually delivers inadequate financial net values (Brukas & Weber, 2009). Additionally, transport cost to remote, not yet harvested, areas need to be considered when investing in roads for harvest only, or also for silvicultural treatments. However, the costs of investing in transport infrastructure are high, and there are uncertainties regarding ownership and long-term maintenance (Naumov et al., 2016).

4.5.3.2.5 Urban development

Urban development has had profound effects on forest. For instance from 1930 to 2000 in Central Asia, overharvesting decreased the area of spruce forests in Kyrgyzstan by 50% (Мусуралиев, Замошников, & Коблицкая, 2000; Токторалиев & Атокуров, 2009). Growing industrialization and population and rise of collective farming increased human-caused fires in forests. In 1954-1960 only 31% of fires were caused by man, while in 1981-1990 this number increased to 66% (Байзаков, 2014). Future change in forested area in Central Asia is likely to be strongly linked to the direct and indirect effects of ongoing climate change in combination with effects from changing demography, economy, technology, lifestyle, and policies (R. H. Moss et al., 2010) (**Figure 4.23**).

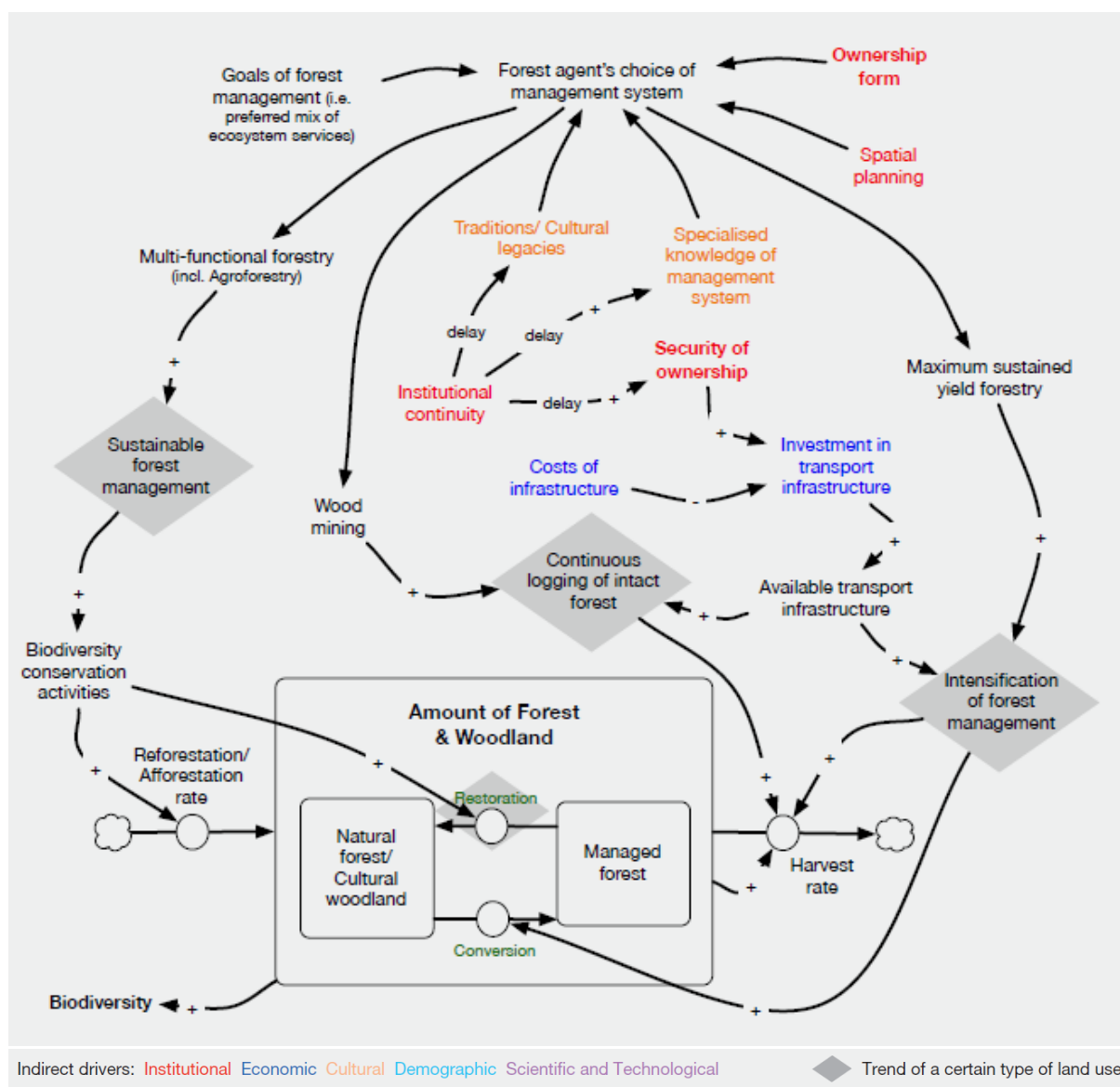


Figure 4.23: The choice of forest management system is influenced by the preferred mix of nature's contribution to people, the form and security of land ownership, and the knowledge and forestry traditions embodied in individual managers. Investment in transport infrastructure, vital to intensive silviculture, is also highly dependent on secure, long-term land ownership (own illustration).

4.5.3.2.6 Radical changes in political, economic and social contexts as triggers of changes in forestry

Since 1991, after the dissolution of the Soviet Union, radical changes in political, social and economic contexts put pressure on forest areas in Eastern Europe and Central Asia, causing a decline in financial resources for forest management, and a decline in control measures. Forest management institutions lacked financial and political support (Байзаков, 2014). At the same time, local households experienced shortages in the supply of oil, firewood and coal, which led to increased illegal logging in rural areas. The regional market for coal and oil collapsed, which increased the use of forest wood for heating purposes. Rise of unemployment and poverty contributed further to forest destruction. For the past 20 years, forest area with tree species such as saxaul, pistache, almond and walnut have been reduced considerably (Demidova, 2013) (Figure 4.24).

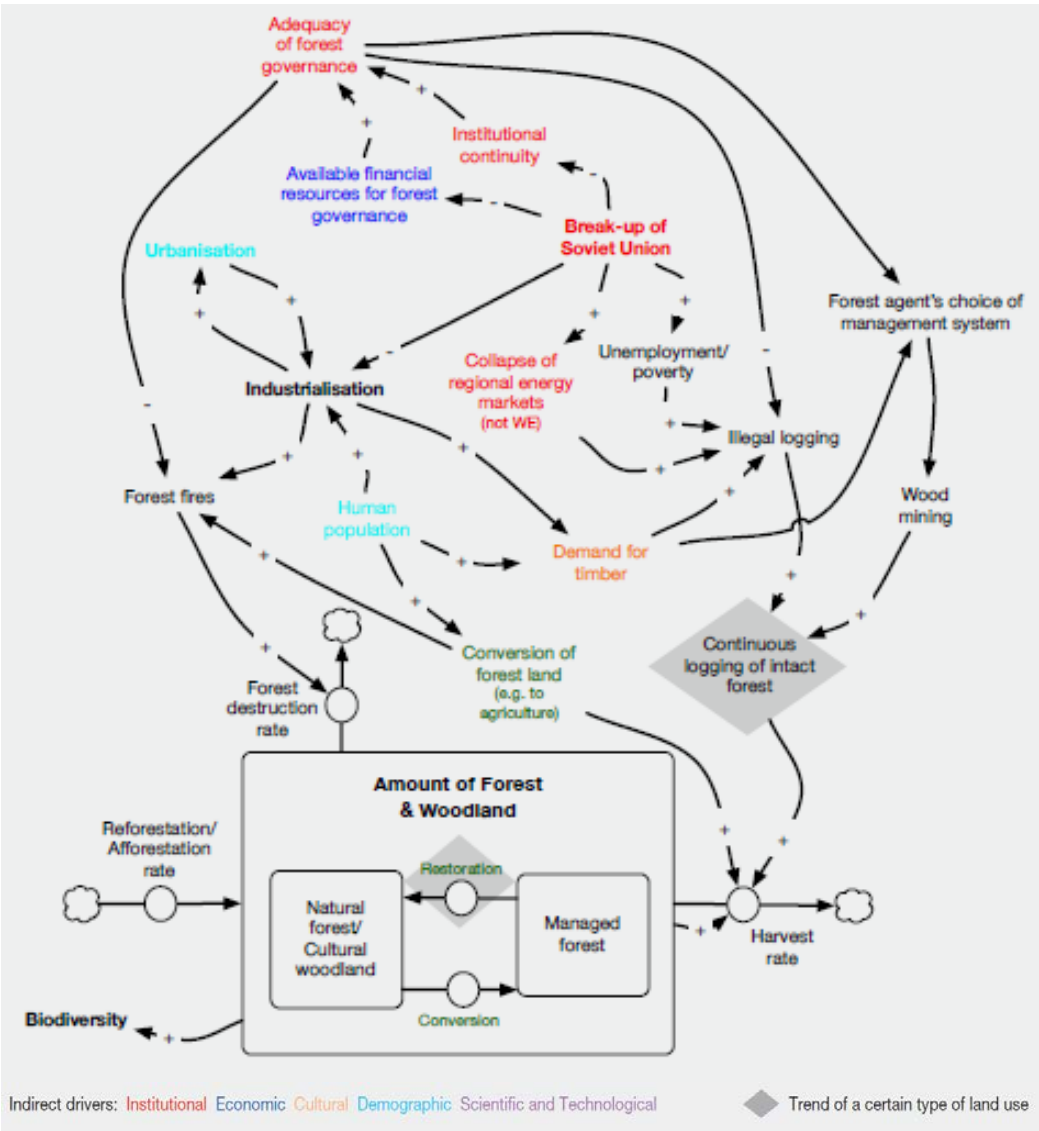


Figure 4.24: Population growth, industrialization and urban development are drivers of demand for timber (own illustration). As a result, a “wood mining” frontier has slowly moved from south-west to north-east Europe during recent centuries, leaving a long-standing legacy of impaired forest biodiversity. The dissolution of the Soviet Union had a variety of institutional impacts on forests, and led to increases in illegal logging in Central and Eastern Europe as well as Central Asia.

4.5.4 Trends and indirect drivers of changes in protected area development

4.5.4.1 Trends in protected area development

In Europe and Central Asia, the total coverage of protected areas is 10.2%, with 13.5% of its terrestrial area and 5.2% of its marine area (within the Exclusive Economic Zone) being protected (**Figure 4.25**) (IUCN and UNEP-WCMC, 2014). Key biodiversity areas cover 5.5% of Europe and Central Asia for Important Bird & Biodiversity Areas and 0.01% for the Alliance for Zero Extinction sites. As of 2017, the proportion of Key biodiversity areas fully covered by protected areas in Europe and Central Asia is 33.3% of Alliance for Zero Extinction sites and 28.1% of Important Bird & Biodiversity Areas.

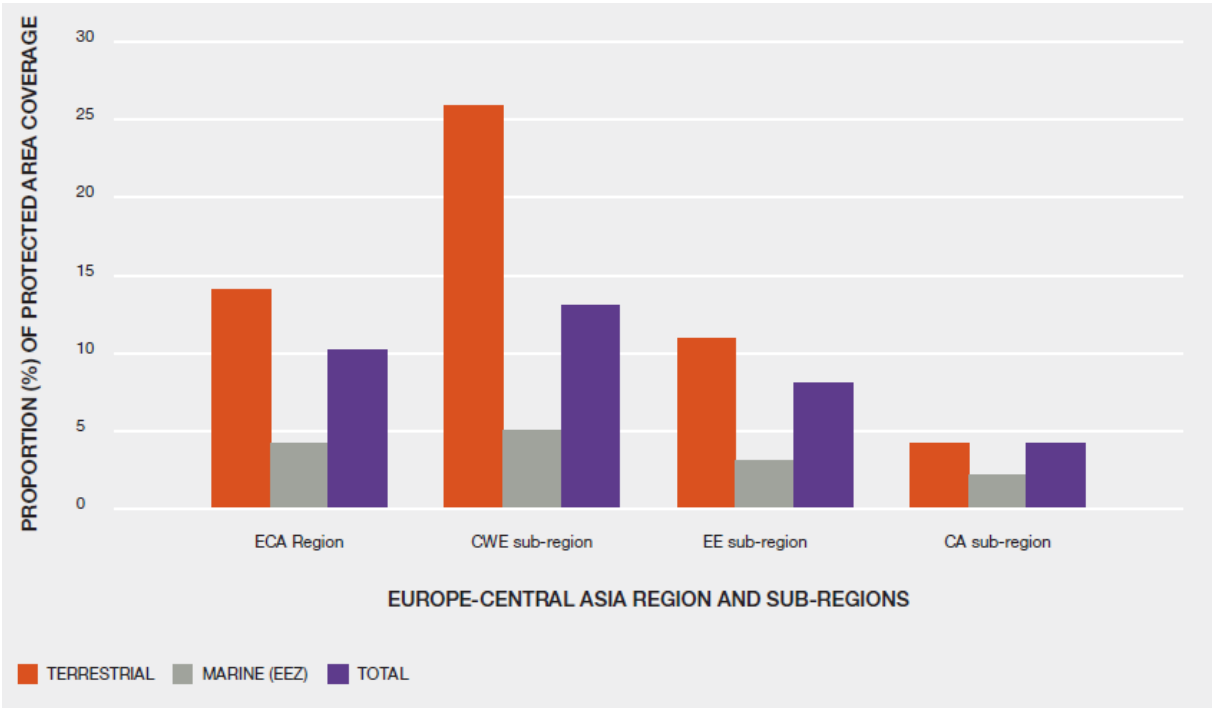


Figure 4.25: Proportion of protected area coverage in Europe and Central Asia and subregions.

In Western and Central Europe, the total coverage of protected areas is 14.9%, with 26.7% of the terrestrial area and 6.8% of the marine area being protected (Figure 4.25). These subregions have the highest proportion of terrestrial and marine areas, and also the highest proportion of protected area coverage in Europe and Central Asia. Key biodiversity areas cover 6.4% of Western and Central Europe for Important Bird & Biodiversity Areas, and only 0.01% for Alliance for Zero Extinction sites. As of 2017, the proportion of Key biodiversity areas fully covered by protected areas in Western and Central Europe is 14.3% of Alliance for Zero Extinction sites and 35.5% of Important Bird & Biodiversity Areas (Figure 4.26). In Eastern Europe, the total coverage of protected areas is 7.5%, with 9.5% of the terrestrial area and 2.9% of the marine area (within the Exclusive Economic Zone) being protected (Figure 4.25). Key biodiversity areas cover 4.8% of Eastern Europe for Important Biodiversity Areas, and 0.01% for Alliance for Zero Extinction sites. As of 2017, the percentage of Key biodiversity areas fully covered by protected areas in Eastern Europe is 100% of Alliance for Zero Extinction sites and 5.42% of Important Bird & Biodiversity Areas (Figure 4.27). In Central Asia, the total coverage of protected areas is 4.1%, with 4.2% of the terrestrial area and 2.4% of the marine area (within the Exclusive Economic Zone) being protected (Figure 4.26). Key biodiversity areas cover 5.4% of Central Asia for Important Bird & Biodiversity Areas, and there are no Alliance for Zero Extinction sites in the subregion. As of 2017, the proportion of key biodiversity areas fully covered by protected areas in Central Asia is 4.65% (Figure 4.27).

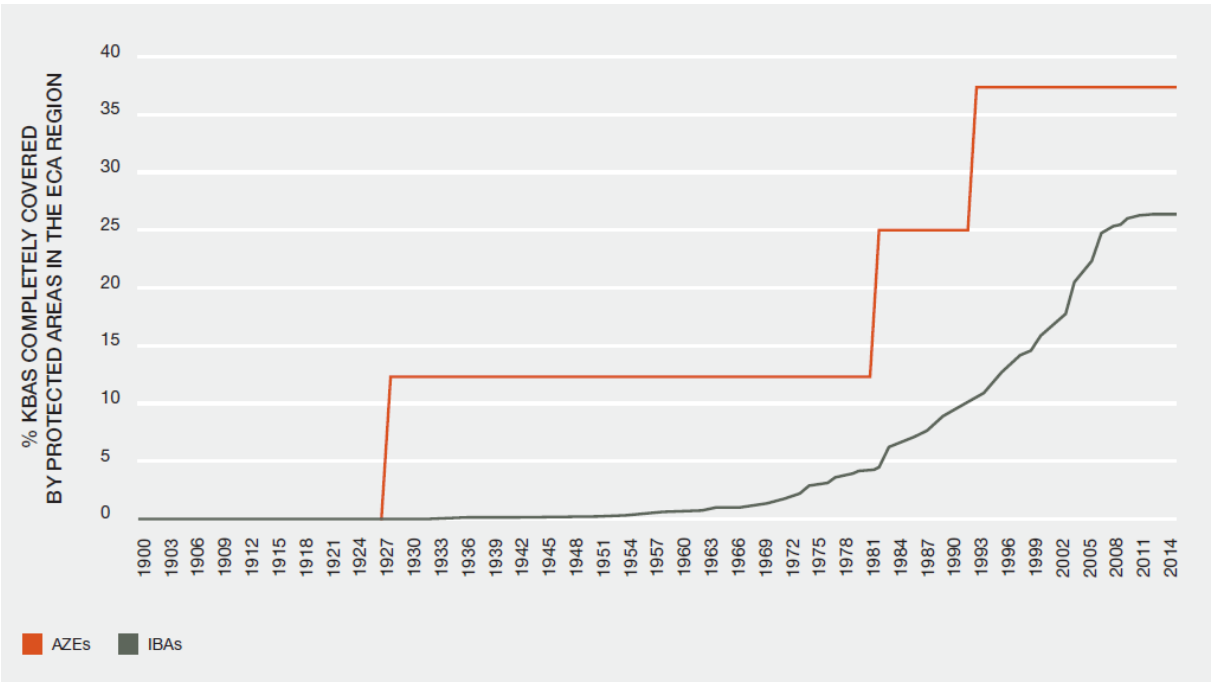


Figure 4.26: Growth in the proportion of key biodiversity areas completely covered by protected areas in Europe and Central Asia.

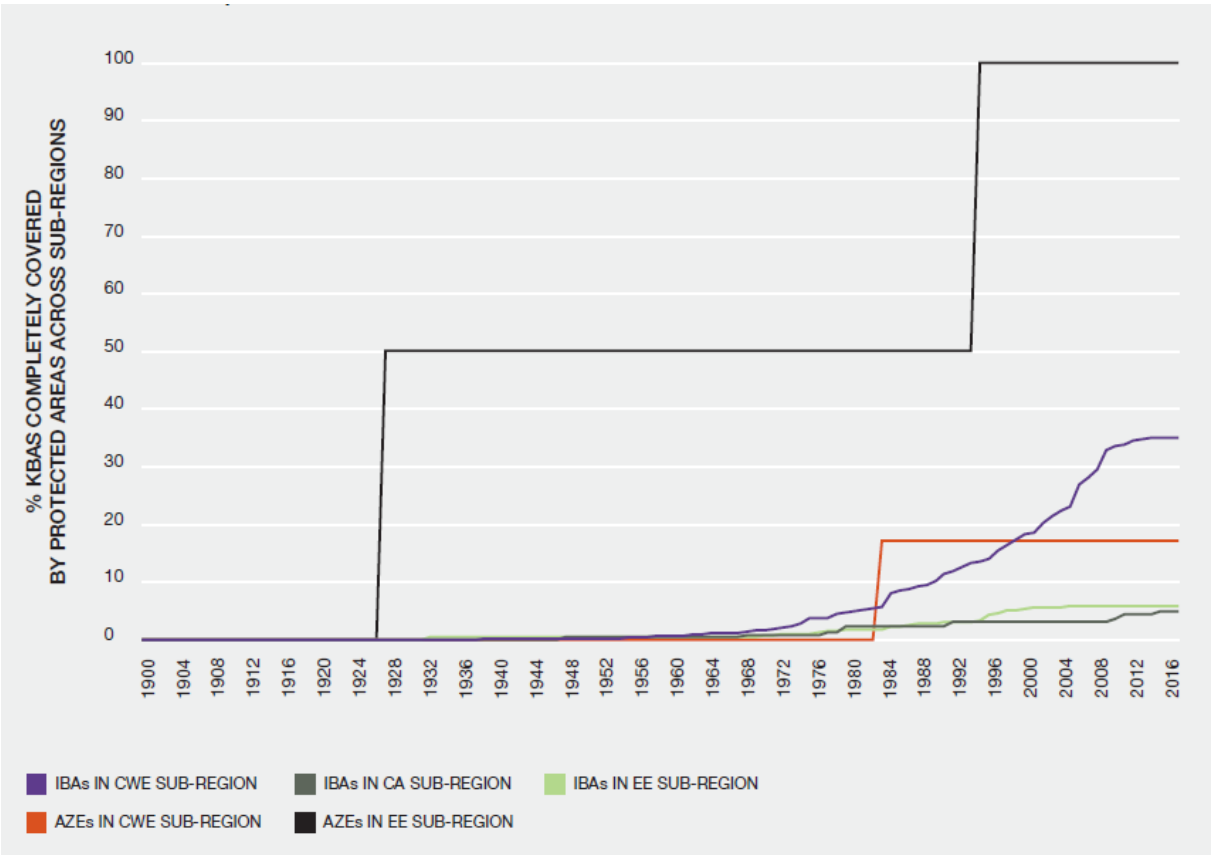


Figure 4.27: Growth in proportion of Key biodiversity areas completely covered by protected areas in subregions of Europe and Central Asia.

The main trend in protected area development in Europe and Central Asia is increasing area under protection. Increase within the European Union has been significant, amounting to about 25% of land cover. Superficially, this suggests that the European Union has already met Aichi Biodiversity Target 11 of 17% protected terrestrial area (Figure 4.25). However, the bio-geographical and ecological representativeness as well as connectivity (e.g., P. Angelstam et al., 2011) of protected area needs further research. Consequently, tools for monitoring and analytic prioritization are clearly needed (Branquart, Verheyen, & Latham, 2008; Rosati, Marignani, & Blasi, 2008; Schultze, Gärtner, Bauhus, Meyer, & Reif, 2014).

Analysis of the development of protected areas in the boreal zone in Western and Eastern Europe over the last 100 years (Elbakidze, Angelstam, et al., 2013) shows that the areal extent of protected areas has increased from approximately 1500 ha in 1909 to 23 million ha in 2010 (Figure 4.28). The area proportion, size and management profiles of protected areas were very different over time among boreal countries. Throughout this 100-year study period, the least productive northern boreal forest was preferentially protected (Figure 4.28 and Figure 4.29). The uneven representation of protected areas among boreal zone in Western and Eastern Europe was maintained over almost the entire previous century and presents a big challenge for boreal forest conservation (e.g. Ilkka Hanski, 2011; Uotila, Kouki, Kontkanen, & Pulkkinen, 2002; Virkala & Rajasarkka, 2007). Another challenge for ecological sustainability is that the vast majority of boreal protected areas are small. According to many studies concerning the requirements of species with different life histories (Belovsky, 1987; Biedermann, 2003; Edenius & Sjöberg, 1997; G. Jansson & Angelstam, 1999; Gunnar Jansson & Andrén, 2003; J. D C Linnell et al., 2005; McNab, 1963; Meffe & Carroll, 1994; Menges, 1991; Roberge & Angelstam, 2004), it is evident that many protected areas are too small for focal and umbrella species such as specialized birds and area-demanding mammals.

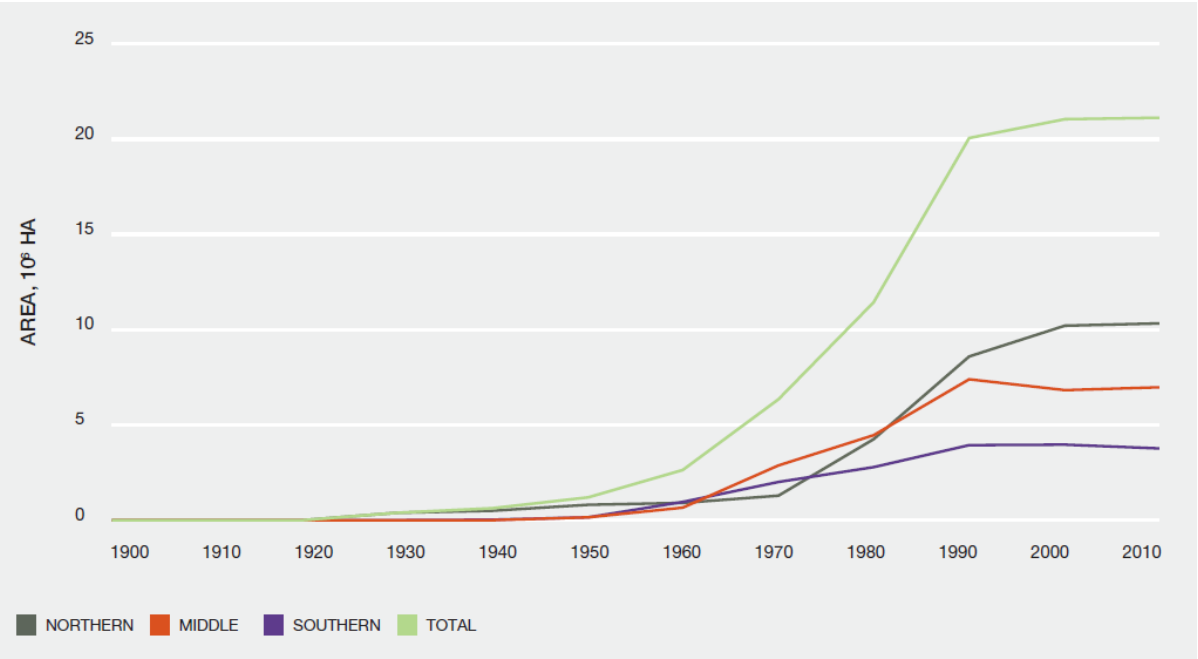


Figure 4.28: Cumulative growth of terrestrial protected areas in northern middle, and southern boreal forests in Western and Central Europe and the European part of Russia by decade (Elbakidze, Angelstam, et al., 2013).

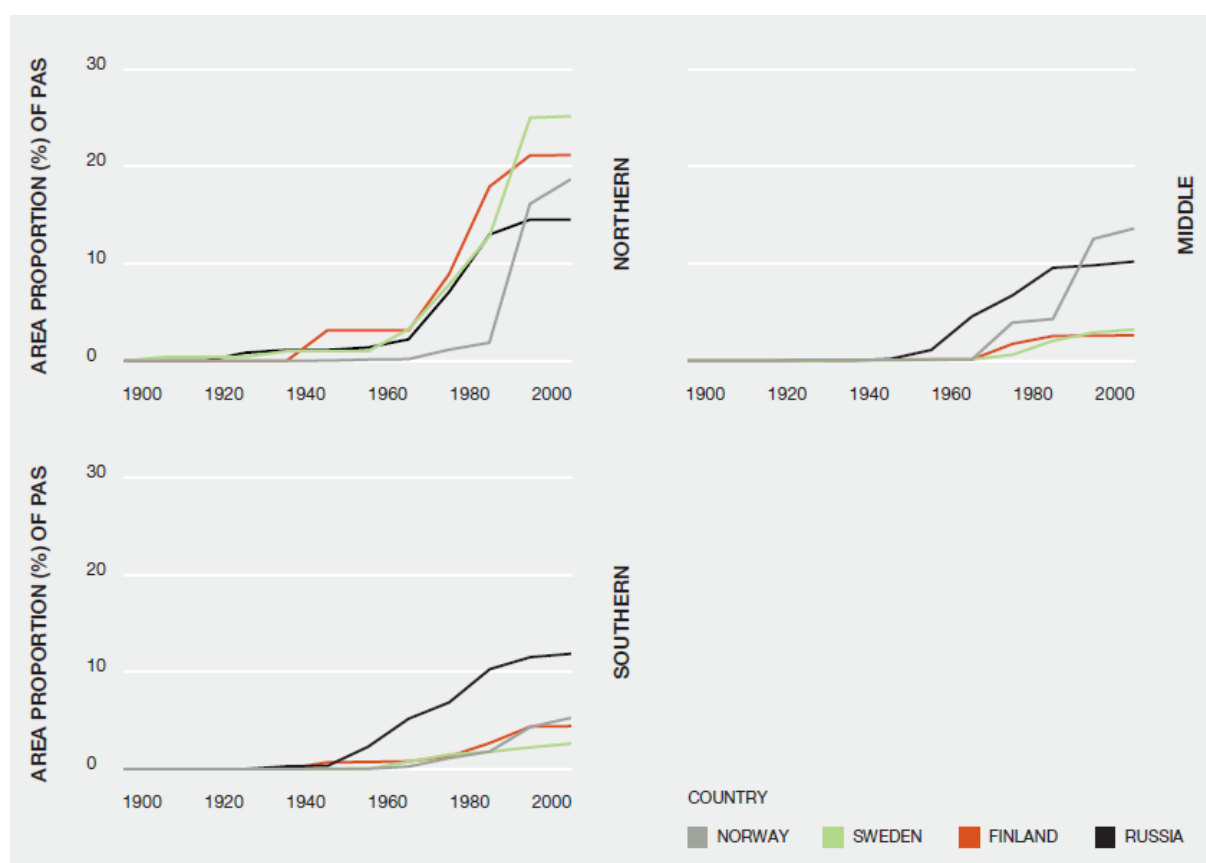
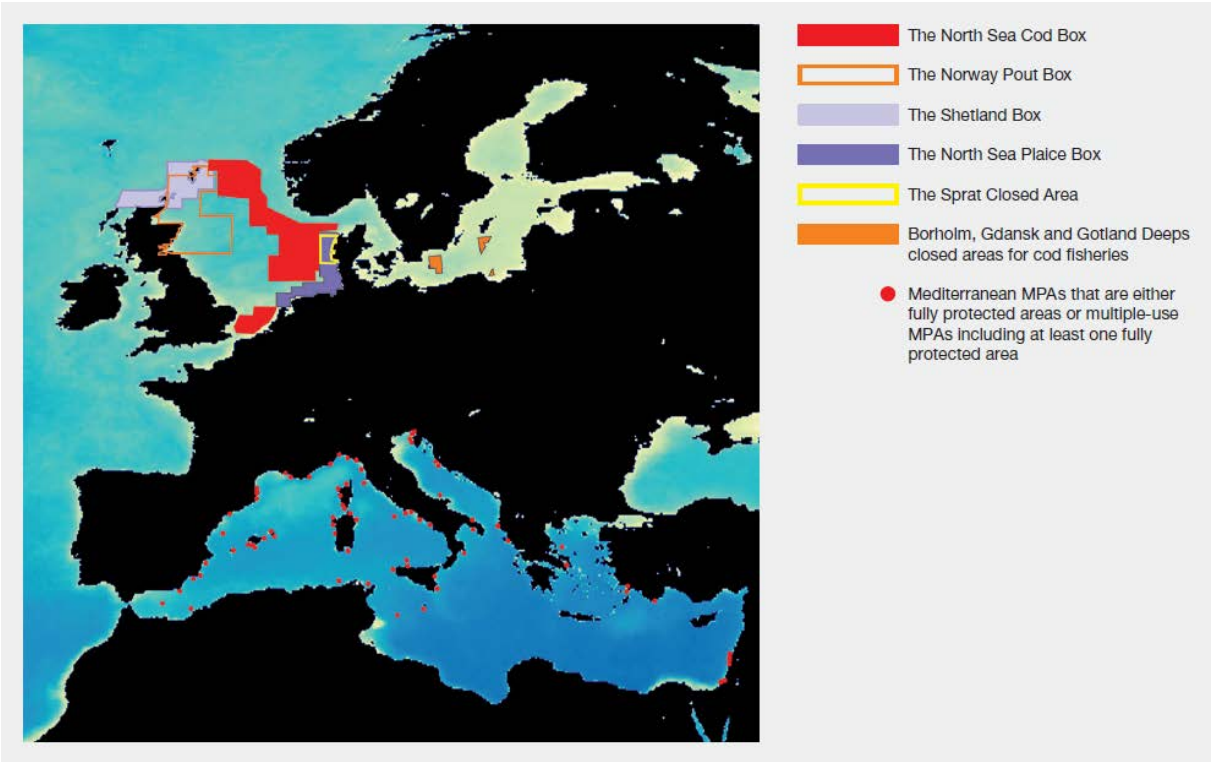


Figure 4.29: Cumulative growth of the area proportion of terrestrial protected areas in northern, middle and southern boreal forests in Western and Central Europe and the European part of Russia (Elbakidze, Angelstam, et al., 2013).

The number of marine protected areas around the world has increased in recent decades, including in the European Union, aiming at the enhancement of local fisheries (G. P. Jones, Cole, & Battershill, 1993; Lubchenco, Palumbi, Gaines, & Andelman, 2003) following the failure of traditional management measures (Batista & Cabral, 2016; Devillers et al., 2015; Fenberg et al., 2012; G. P. Jones et al., 1993; Lubchenco et al., 2003; Waters, 1991). Marine protected areas are generally strongly advocated as an ideal tool for resource management – specifically of coastal fisheries, as well as for preserving biodiversity (Agardy & Tundi Agardy, 1994; Costello & Ballantine, 2015; Dugan & Davis, 1993; Gaines, Lester, Grorud-Colvert, Costello, & Pollnac, 2010; Lubchenco & Grorud-Colvert, 2015; Plan Development Team, 1990; C. M. Roberts & N.V.C., 1991). In 2016, Mediterranean Marine Protected Area Network and Regional Activity Centre for Specially Protected Areas reports 1231 marine protected areas in the Mediterranean covering 18 million hectares, or 7.1% (MAPAMED, 2017) (<http://www.medpan.org/en/mapamed>) (Figure 4.30). The expectation is that marine protected areas will continue to increase in number and area across the Mediterranean and North East Atlantic (Figure 4.31).

However, marine protected areas design differs between Atlantic and Mediterranean areas (Angel Pérez-Ruzafa, García-Charton, & Marcos, 2017). Northern marine protected areas (the so-called fish boxes or fisheries closures; Pastoors, Rijnsdorp, & van Beek, 2000) generally cover hundreds of thousands of hectares, and are intended to protect one or more target or by-catch species (e.g., plaice, sole, cod, herring, sprat, haddock). Mediterranean marine protected areas (Fenberg et al., 2012; Planes, García-Charton, & Pérez Ruzafa, 2006), meanwhile, usually over hundreds of hectares or less (Gabrié et al., 2012; Portman, Nathan, & Levin, 2012), are in general located in areas that are

19529 biologically unique. Both types include differences in management strategies that can affect their
19530 efficiency as fisheries and biodiversity conservation tools (Angel Pérez-Ruzafa et al., 2017).



19531
19532 **Figure 4.29: Distribution of marine protected areas in Western and Central Europe.**

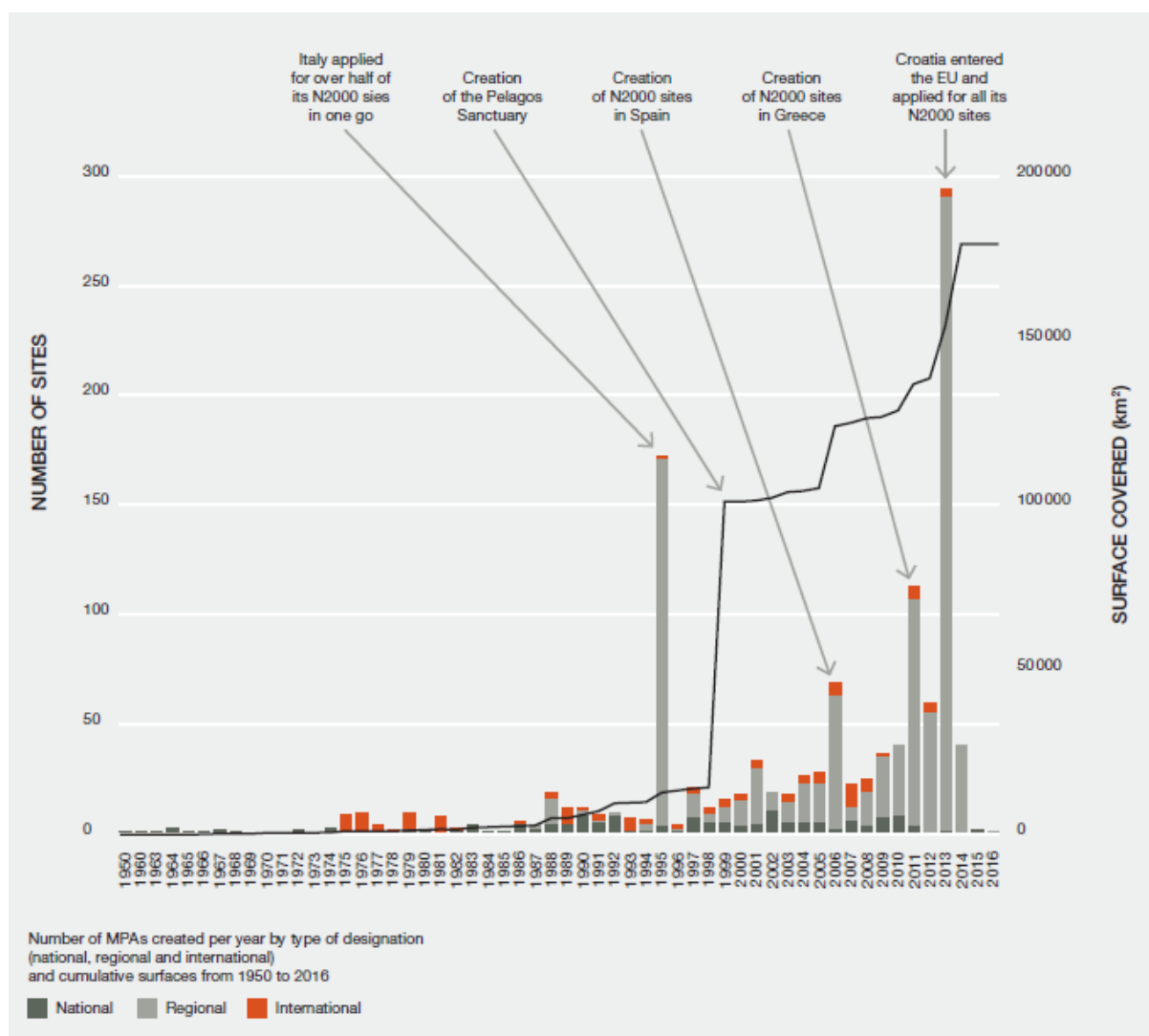


Figure 4.30: Trends in the number and cumulative surfaces of marine protected areas created per year and type of designation (national, regional and international) from 1950 to 2016 (source: MEDPAN, 2017).

4.5.4.2 Indirect drivers of trends in protected area development

There are several key drivers of protected areas in Europe and Central Asia (Figure 4.32) that are unpacked below in Figures 4.34 – 4.40.

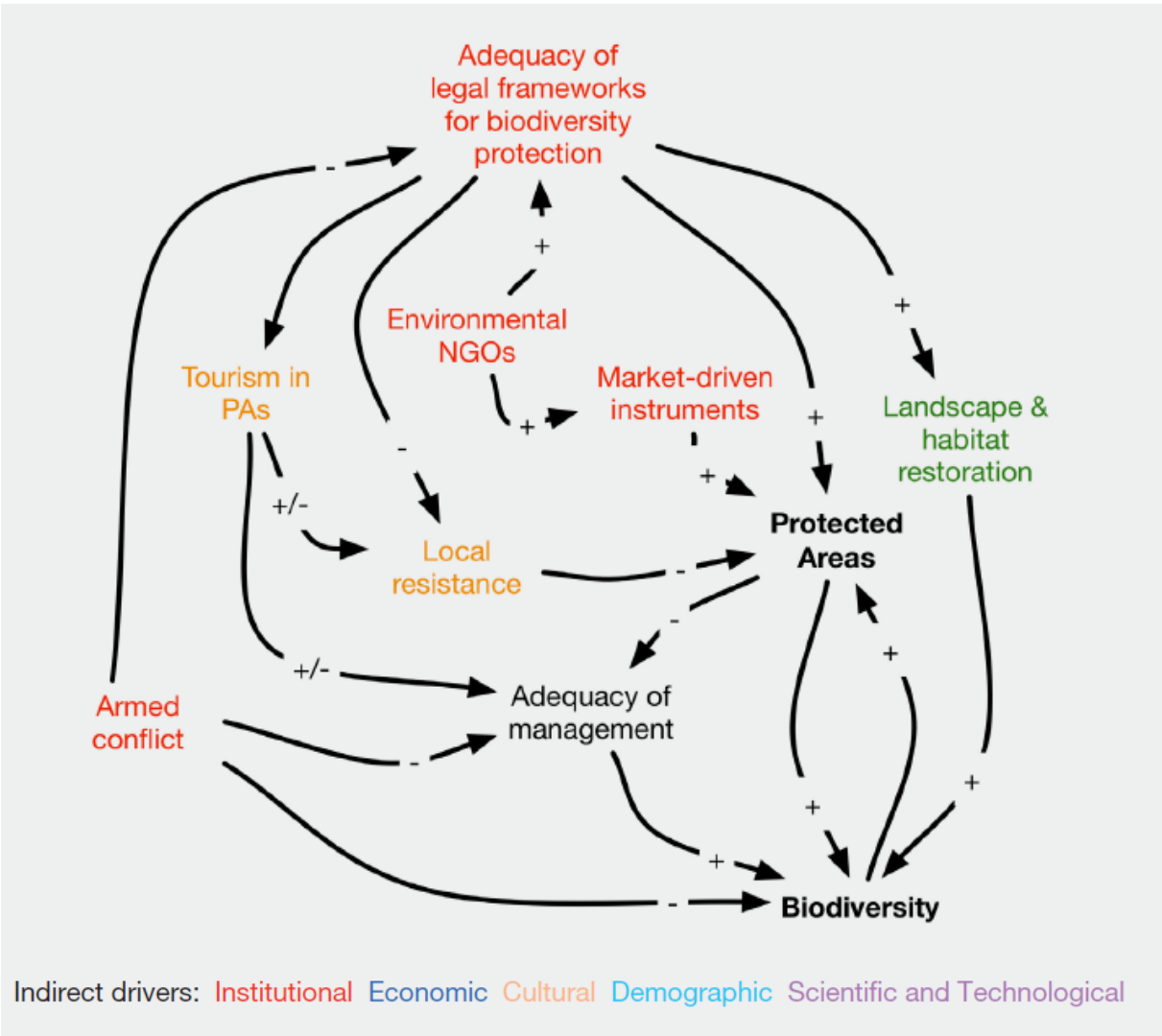


Figure 4.31: An overview of causal interconnections between the major drivers of protected area development in Europe and Central Asia (own illustration). Legal frameworks, particularly international agreements, have led to increased levels of biodiversity protection throughout the region. However, the general inadequacy of institutions for navigating local resistance to protected areas and regulating the negative impacts of tourism poses important problems. These drivers and interconnections are further unpacked in sub-model structures below.

4.5.4.2.1 Legal frameworks

An increasing number of global, regional and national legal frameworks have been a key driver of protected area development in Europe and Central Asia. Agreements such as the Convention of Biological Diversity (CBD, 2010b) and associated Aichi Biodiversity Targets, have led to the adoption of a number of strategic plans and quantitative targets for protected areas. Underpinning these agreements is a growing public environmental awareness, which has influenced policy on nature protection. Another key factor has been the growing body of scientific knowledge on biodiversity and nature’s contributions to people. Improved understanding regarding the negative effects of habitat fragmentation on ecological functionality, for example, has led to the consideration of functional networks of protected areas, at multiple scales, as a means of addressing biodiversity loss (e.g.,

European Commission, 2013; Hodge, Hauck, & Bonn, 2015)(see also Aichi Biodiversity Target 11 – “protected areas increased and improved”).

In response to international agreements, most countries in Europe and Central Asia have developed national biodiversity strategies, in most cases including quantitative targets for protected areas (cf. <https://www.cbd.int/nbsap/>). In Western Europe, international plans and targets are mirrored in the EU Biodiversity Strategy (EU Parliament, 2012) and directly linked to the European Union Species and Habitats Directive. These are subsequently enacted through national legislation. There is strong evidence that supranational conservation policy can bring measurable conservation benefits, although future assessments will require the setting of quantitative objectives and an increase in the availability of data from monitoring schemes (Donald et al., 2007).

As a result of various bilateral agreements, a number of Eastern European countries (e.g. Ukraine, Belarus) are also in the process of harmonising national biodiversity protection legislation in line with European Union directives (e.g. regarding Natura 2000, and the Pan European Ecological Network). However, European Union policies are primarily based on Western European experiences. Numerous studies have shown cases where nature conservation legislation has underperformed when transplanted into new regional or local contexts (e.g. Aksenov et al., 2014; Kuemmerle et al., 2007; Wendland et al., 2015) and a risk remains that European Union-developed approaches will prove either inefficient or inappropriate for supporting biodiversity associated with cultural landscapes in Eastern Europe and Central Asia. Additionally, in some cases the adoption of national strategies has led to unforeseen transboundary consequences. For example, forest protection in China and Finland have both resulted in increased harvest of old-growth forests in neighbouring regions of Central Asia and north-western Russia (Mayer et al., 2006) respectively. Also, some countries have weakened national and sub-national protection regulations largely in favour of regional economic development (see **Box 4.3** and **Figure 4.33**).

Regarding the Marine Protected Areas, for example, the European Union Marine Strategy Framework Directive requires that member States should reach Good Environmental Status of their waters by 2020. The strategy sees establishment of a coherent network of Marine Protected Areas as one of the approaches to fulfil this aim. It specifically refers to Maritime Spatial Planning based on ecosystem based approach as a key tool to reinforced the objectives of the European Union Marine Strategy (Douvere & Ehler, 2009; Ehler, 2008).

Experience shows that these are not empty words. A study published in Marine Policy earlier this year assessed plans in Western and Central Europe, Australia and the USA. They found that planning led to a host of benefits for the environment: it increased marine protection, ensured that industrial uses avoided sensitive habitat, cut carbon emissions, and reduced the risk of oil spills.

Box 4.3: Example of dynamics in legal frameworks from Eastern Europe

In the Russian Federation, despite adopting several fundamental legal documents, and subsequent rapid growth in protected areas during the 1990s, numerous laws or amendments have recently been passed to weaken the protection status of existing protected areas, primarily in favour of increased economic activity (Бриних, 2016; НИИ-Природа, 2016. For example, in preparation for the Sochi Olympics an amendment was made in the law "On Specially Protected Natural Areas" allowing the construction of sports infrastructure in national parks. This amendment set legal preconditions for use of lands within national parks by new ski resorts. The governmental program "The main directions of the state policy on the development of the system of state nature reserves and national parks in the Russian Federation for the period until 2015", adopted by the Ministry of Natural Resources of Russia in 2003, was not able to stop the subsequent degradation of protected areas. Recent changes in water and forest legislation led to a weaker legal regime in the areas of water protection zones and protective forests (Naumov et al., 2017). In 2013, a law was passed that eliminated the principle of perpetuity of existence of

protected areas and initiated transformation of strict nature reserves into national parks. In 2016, another law was adopted allowing the allocation of biosphere polygons within the boundaries of biosphere reserves, which legalized economic development (Бриних, 2016; НИА-Природа, 2016). Other amendments were made to the federal law "On Territories of Traditional Nature Use of the Indigenous Minorities of the North, Siberia and the Far East of the Russian Federation" (2001), according to which such territories are not considered any more as Specially Protected Natural Areas; currently it creates new challenges in the procedure of their creation. Since 2001, not a single territory of traditional land management of indigenous people of Federal importance has been created (НИА-Природа, 2016). At national and regional levels, there are no legal frameworks that take into account the specific nature of conservation of steppe landscapes (Чибилёв, 2015).

End of Box 4.3

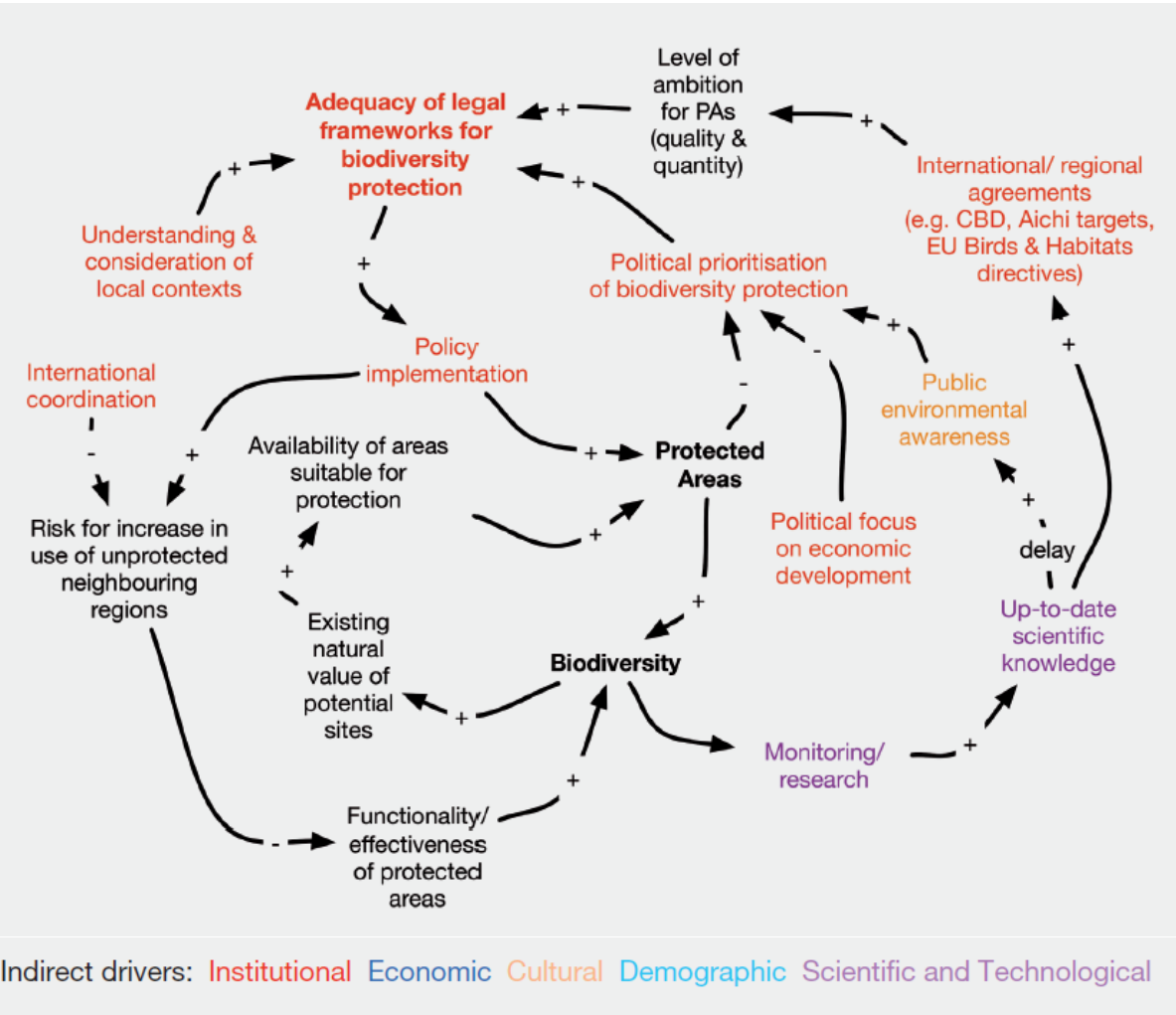


Figure 4.32: The prioritization and implementation of adequate legal frameworks for protected areas development has largely been driven by the adoption of international agreements, as well as an increasing public environmental awareness (own illustration). A strong political focus on economic development goals, however, has in many cases delayed the development, and in some cases, has led to the weakening, of adequate policies.

4.5.4.2.2 Forest certification

Industries have largely adopted certification requirements in response to increased consumer demand for environmentally responsible products, as a result of heightened public environmental awareness globally and across Europe and Central Asia. Voluntarily set-asides, driven in large part by the

requirements of various production certification schemes, are also important for protected areas in Europe and Central Asia. For example, market-driven forestry certification schemes require that a certain fraction of the certified forest holding is set-aside for biodiversity conservation (often around 5% of the land holding, e.g. www.fsc.org). Certification systems highlight protection of forest areas as a means to maintain forest biodiversity (FSC, 2016; PEFC, 2010) and hence their national standards regularly include targets for voluntary set-asides. Both increased forestry certification as well as the adoption of national and global targets for protected areas have resulted in an increased area of formally protected forests and voluntary set-asides for biodiversity conservation purposes.

4.5.4.2.3 Activity of environmental non-governmental organizations

Environmental NGOs are among the key actors in shaping general public environmental awareness across Europe and Central Asia (Benjamin Cashore et al., 2003; Meidinger, 2003; M Tysiachniouk, 2012; Maria Tysiachniouk & McDermott, 2016). Public awareness has proved influential in creating a greater political prioritization of nature protection, as well as steering consumer preferences towards environmentally certified products. NGOs have also actively and directly lobbied industries and decision-makers to develop stricter (self-)regulatory frameworks for nature protection (e.g. marine protected areas) and to otherwise engage with various certification systems. In Eastern Europe, environmental NGOs – largely supported by foreign donors – contributed considerably to protected area development and management during the long post-Soviet transition towards a market economy. (e.g. “Заповедники России. Сборник материалов Летописей природы за 1991/1992,” 1994), developed strategic and management plans for protected areas (e.g. *Охраняемые природные территории*, 1999), designed regional protected areas and ecological networks, coordinated ecological restoration projects, as well as carrying out many other activities. However, the last decade has seen an increase in legal and administrative pressure on the activities of environmental NGOs in some Eastern Europe countries. For example, in Russia the official list of foreign NGOs permitted to operate in the country has been reduced by 7 times, and since 2008 consists of only 12 organizations; NGOs receiving any form of foreign funding are frequently classified as “foreign agents” (Шевченко, 2016). Russian environmental NGOs have seen funding liquidated, or have otherwise been forced to gradually cease their activities (“О проблемах финансирования проектной деятельности эконоНПО,” 2009). Under such circumstances, the activity of many NGOs cooperating with protected areas in Russia has decreased considerably (Бишоп, Грин, & Филлипс, 2000; Бриних, 2016; *Разработка планов управления (менеджмент-планов) для особо охраняемых природных территорий*, 2006, *Степные пожары и управление пожарной ситуацией в степных ООПТ: экологические и природоохранные аспекты. Аналитический обзор*, 2015; Степаницкий & Крейндин, 2004; Штильмарк, 2003) (**Figure 4.34**).

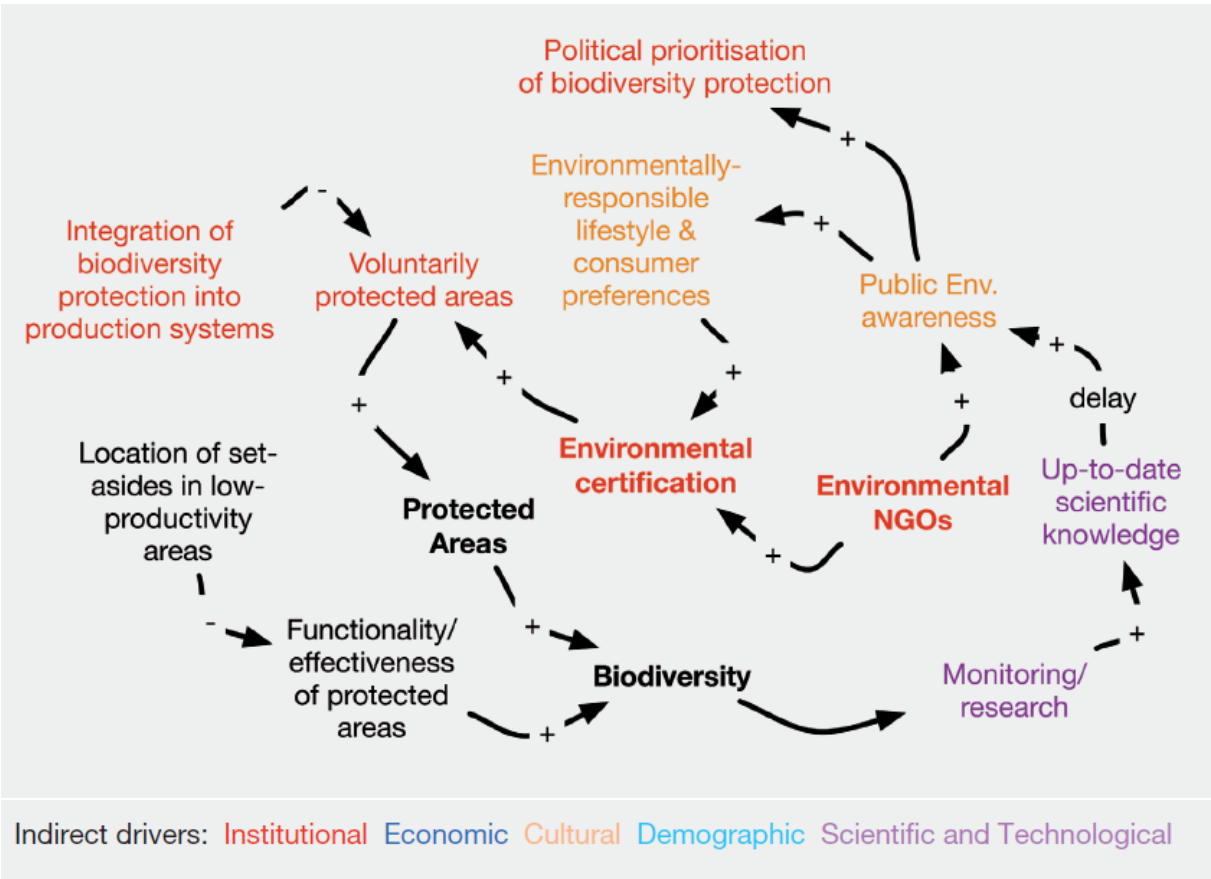


Figure 4.33: Environmental NGOs have had an important impact in building public awareness of the role of nature protection, leading to shifts in consumer preferences and political priorities (own illustration). The drive to environmental certification has been important provider of voluntary protection.

4.5.4.2.4 Adequacy of management resources for protected areas

The availability of state-based funding for protected areas varies across Europe and Central Asia. In some countries state funding is insufficient for adequate management (Степаницкий, 1999, 2000). Funding from external bodies, for example, European Union environmental funds and international NGO funding, has in some instances bolstered protected area management budgets. In some countries there are, however, a number of institutional impediments to accessing such funding. Recent changes to laws in Russia (see **Box 4.3**), for example, have had a negative influence on protected areas funding (Шевченко, 2016). Many protected areas also seek to augment management budgets by generating income opportunities based on protected area resources, for example through forestry or tourism. Managing these kinds of use often requires additional resources, and has an adverse impact on the natural values provided by the protected areas. In addition, acquisition costs for protected areas are generally much higher than annual management costs and have a strong impact on the financial resources available for protection (James, Gaston, & Balmford, 1999). As such, high land prices can present barriers for biodiversity protection in areas where land must be purchased prior to the establishment of protected areas, with intensive land uses generally associated with higher prices (Naidoo et al., 2006).

Protected area management also requires sufficient training of managers or the procurement of a variety of specialists, both of which represent additional costs. Inadequate training of young specialists

has been identified as a barrier to good management in some Eastern European countries (e.g. Мишин, Козлов, & Никольский, 2001), where the previous, Soviet-trained generation of managers is beginning to retire. Up-to-date scientific knowledge is partly dependent on taking local contexts into account in high-quality research. In addition to formal knowledge and training, the inclusion of local knowledge is seen as an important component in ensuring adequate management (Богословская & Вдовин, 2005; Вдовин, 2016; Шульгин, 2007) (Figure 4.35).

Whilst staff are often driven by a strong desire to preserve unique natural values, low salaries (Иванов & Чижова, 2003) together with often poor working conditions and a general lack of focus on long-term capacity building, this has led to the demotivation of staff (Машкин, 2007; Сиденко, 2010). Many protected areas are also reliant on the contribution of civil sector volunteers (e.g. members of NGOs or local communities). However, the degree to which these human resources are permitted to contribute to protected area management is partly dependent on the inclusion of suitable participatory mechanisms in the overall governance and management approach.

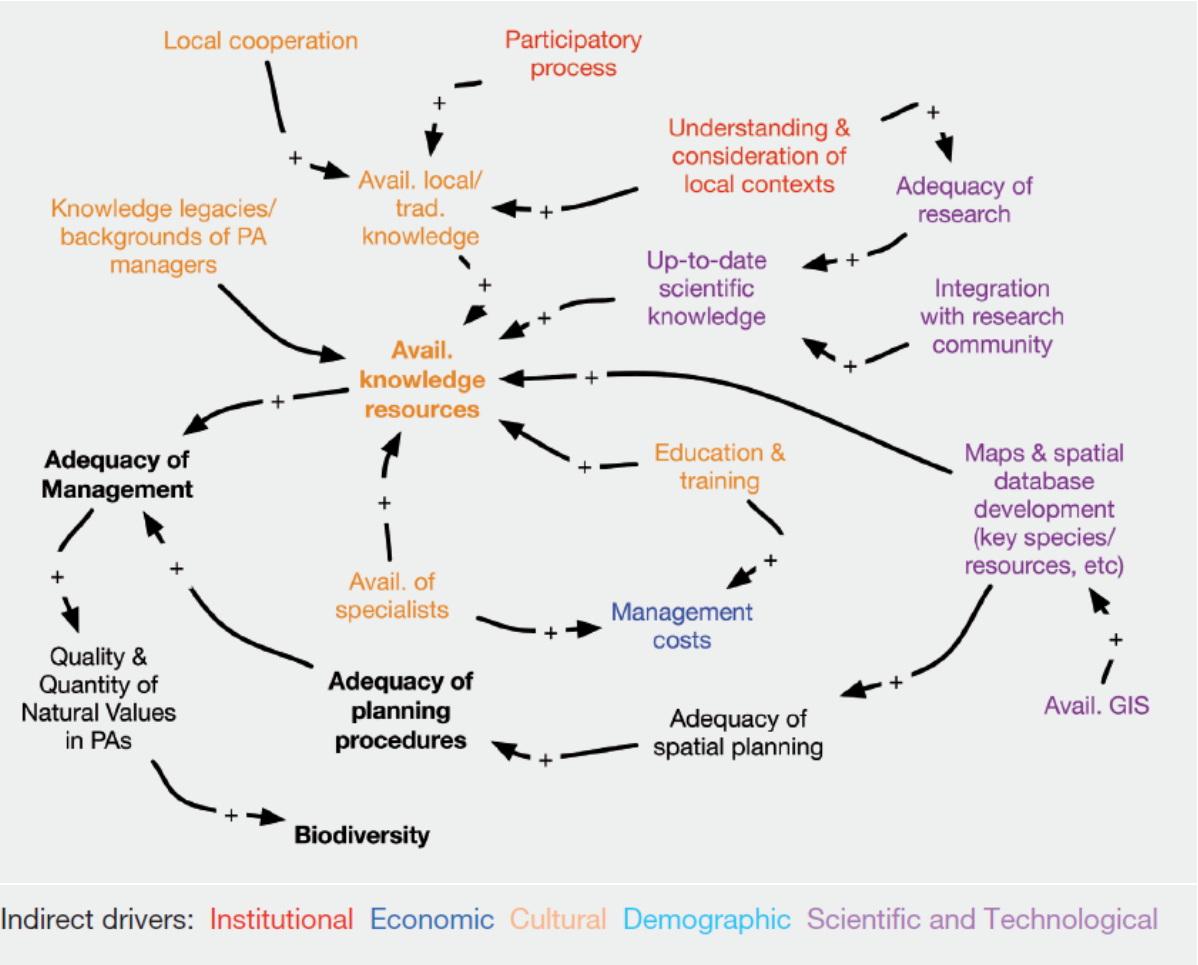


Figure 4.34: Knowledge and planning resources are essential to adequate protected area management (own illustration). The education and training of staff and integration of management with both research and local communities are key strategies.

Specialized equipment (e.g. GIS, computerized species-monitoring systems) is often required to establish the baseline data for, or monitor the impacts of, protected area strategies and plans. Other more generic forms of technology, such as suitable vehicles, and infrastructure, such as protected area management offices, are also required inputs. In broad terms, many Eastern European and Central

19711 Asian protected areas suffer from poor quality or out-dated equipment, infrastructure and vehicles, or
 19712 lack these entirely.

19713

19714 4.5.4.2.5 Local resistance

19715 A major factor affecting the establishment or successful management of protected areas in Europe
 19716 and Central Asia relates to the manner in which they navigate local use conflicts arising as a result of
 19717 protection status and management (D. Babai, Molnár, & Biró, 2016). Protected area governance and
 19718 management regimes are often characterized as top-down with low levels or quality of public
 19719 participation; inflexible responsible authorities and insufficient consideration of the local context;
 19720 engendering negative public perceptions; and resistance amongst members of local communities
 19721 (Blicharska, Orlikowska, Roberge, & Grodzinska-Jurczak, 2016; Carrus, Bonaiuto, & Bonnes, 2005;
 19722 Elbakidze, Hahn, Mauerhofer, Angelstam, & Axelsson, 2013; Grodzinska-Jurczak & Cent, 2011;
 19723 Mathevet, Thompson, Folke, & Chapin, 2016). These factors pose significant challenges to the
 19724 functionality of protected area networks (Blicharska et al., 2016; Elenius, Allard, & Sandström, n.d.;
 19725 Stenseke, 2009).

19726 Local resistance to protected areas can be related to in-group/out-group identity processes, e.g. local
 19727 communities vs central governmental authorities (Bonaiuto, Carrus, Martorella, & Bonnes, 2002; Stoll-
 19728 Kleemann, 2001), or from the perceived loss of user rights as a result of protected areas' restrictions
 19729 (James et al., 1999). For the latter reason, land owners tend to oppose establishment of protected
 19730 areas to a greater extent than other stakeholders (Brescancin, Dobšínská, De Meo, Šálka, & Paletto,
 19731 2017; Kamal & Grodzinska-Jurczak, 2014), particularly in countries where social values are strongly
 19732 linked to long histories of private ownership. At the same time, local identity in some cases is also
 19733 linked to reduced local resistance due to strong socio-cultural links to nature (Carrus et al., 2005; Uzzell,
 19734 Pol, & Badenas, 2002).

19735 The mutual dependence of extensive land use and conservation management has become apparent
 19736 in the last 20-30 years. Small-scale extensive land use often survives in protected areas only, in the
 19737 form of conservation management, and is largely side-lined in regulatory frameworks. Regulations
 19738 introduced to protect such areas often apparently do not consider local world views, or the effects of
 19739 local practices. This results in the restriction of local people's activities (D. Babai et al., 2016; Zsolt
 19740 Molnár et al., 2016) and conflict between locals and the protected area's authority (Kelemen et al.,
 19741 2013). The adoption of a more integrated, participatory approach to the governance and management
 19742 of protected areas is suggested as a potential remedy to local use conflicts, particularly in protected
 19743 areas established in cultural, small-scale, or indigenous landscapes. There is a need for "hybrid people"
 19744 who have knowledge of traditional practices and world views, as well as of mainstream nature
 19745 conservation ideas (Zsolt Molnár et al., 2016). Additionally, the introduction of agro-environmental
 19746 schemes in protected areas can mitigate the loss of traditional management practices and so prevent
 19747 biodiversity loss accompanying land abandonment (Dániel Babai et al., 2015). One approach might be
 19748 for landscape- and culturally-specific agricultural regulatory frameworks and subsidy systems that
 19749 include local and traditional knowledge to produce tailored local solutions that respect the strong link
 19750 between natural and cultural capital (Zs Molnár & Berkes, 2017) (**Figure 4.36**).

19751 Marine protected areas appear to have been more successful than terrestrial ones in combining
 19752 conservation plans and management practices with visible economic benefits in terms of long-term
 19753 fishery management and diving-based tourism. Marine protected area design takes greater account of
 19754 geographical and cultural contexts in which users are situated (Fenberg et al., 2012; Gabrié et al., 2012;
 19755 Pastoors et al., 2000; Planes et al., 2006; Portman et al., 2012). However, while aiding local acceptance

of marine protected areas, a strong consideration of the needs of multiple users within the local context has potentially led to the protection of areas of lower inherent conservation value (Coll et al., 2012).

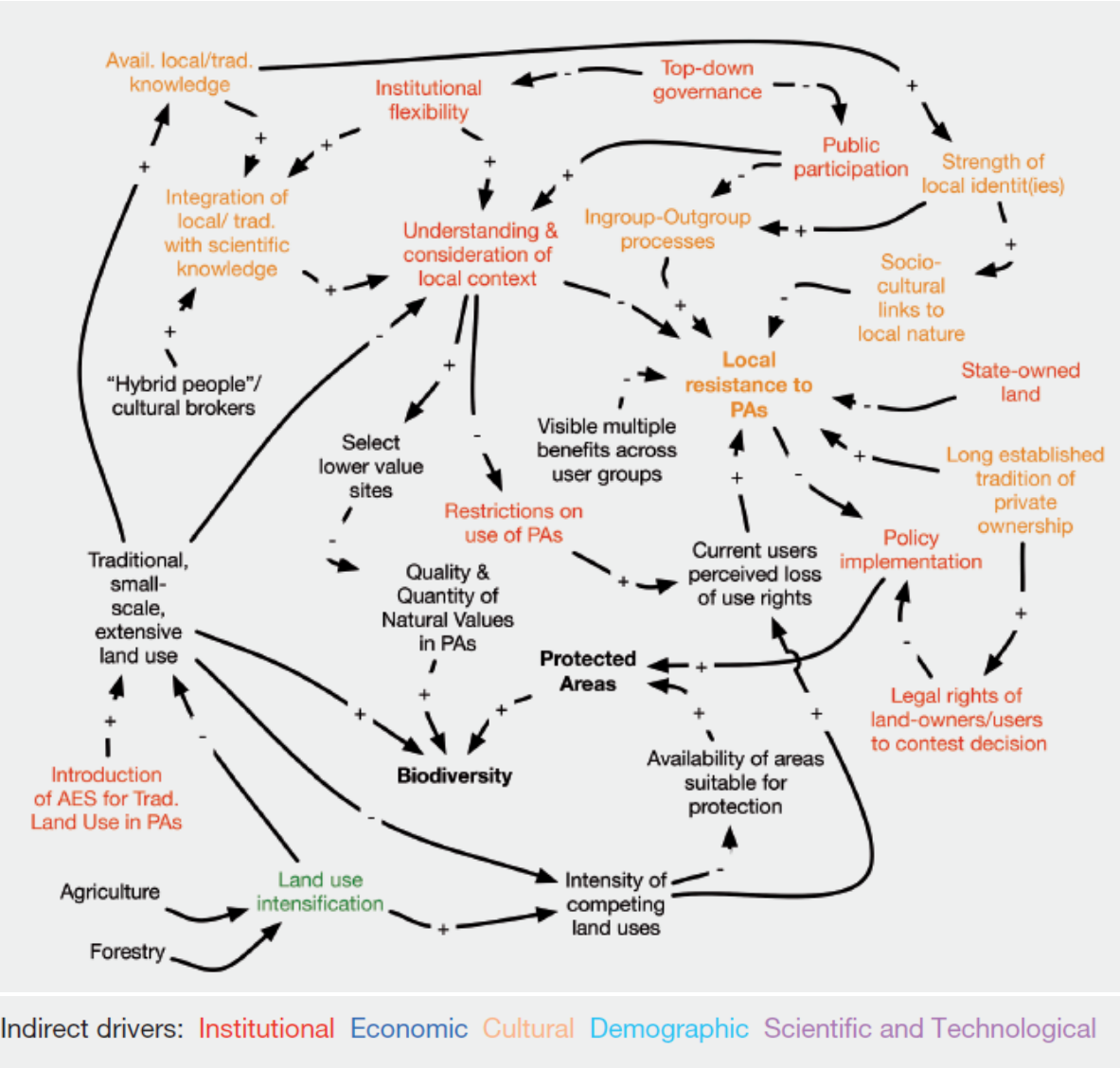


Figure 4.35: Consideration of local contexts, knowledge and identities in the design and establishment of protected areas helps to avoid local resistance (own illustration).

4.5.4.2.6 Armed conflicts

Armed conflicts have multiple negative impacts on biodiversity and nature’s contributions to people. Europe and Central Asia is unfortunately the arena for a number of recent and current armed conflicts (Vasyliuk, Shyriaieva, Kolomytsev, & Spinova, 2017). Whilst few studies have been conducted in the region on the specific effects of armed conflict on protected areas, the environmental effects are presumed to be identical to those in non-protected areas and include the various forms of direct environmental damage associated with the use of heavy weapons and military equipment, as well as a number of effects resulting from sudden changes in land-use regimes (see **Box 4.4**). It is apparent that legal protection status is not well-respected during times of armed conflict. Studies of conflicts outside of Europe and Central Asia suggest that protected areas, which are often remote or difficult to

19774 access, serve as refuges for fighting forces, and as such are key targets for opposing forces (D'Huart,
 19775 1996). In addition, armed conflicts exacerbate poaching pressure and other illegal use, immediately
 19776 eliminate tourism activities, and drain financial and human resources from ecosystem management
 19777 (Matthias Baumann, Radeloff, Avedian, & Kuemmerle, 2015; D'Huart, 1996; de Merode et al., 2007; J.
 19778 P. Dudley, Ginsberg, Plumptre, Hart, & Campos, 2002) (**Figure 4.37**).

19779 **Box 4.4: Consequences of armed conflicts for biodiversity and nature's contributions to people -**
 19780 **example from Ukraine**

19781 Since 2014, armed conflict in the eastern region of Ukraine (Luhansk and Donetsk), in addition to a large number
 19782 of human casualties and the destruction of infrastructure, has led to extensive habitat loss in existing protected
 19783 areas, largely due to:

19784 (1) Heavy military machinery driving or otherwise operating in protected areas.

19785 (2) Explosions of munitions, resulting in the destruction of vegetation and accumulation of debris and chemicals
 19786 in soils - primarily sulphur and heavy metals, e.g. experts counted about 15,500 craters from explosions in the
 19787 regional landscape park "Donetsk ridge".

19788 (3) Construction of military infrastructure, e.g. training grounds and trenches, within protected areas.

19789 (4) Illegal logging for military purposes and fires. Pine forests of the steppe zone of Ukraine are extremely fire-
 19790 prone. About 3000 fires occurred in the military zone within protected areas during 2014. Roughly half of all
 19791 protected areas in the war zone are fire-damaged.

19792 (5) Illegal logging by local people for domestic needs, associated with the destruction of regional heating systems
 19793 and gas supply; as well as for the construction of defensive infrastructure. This has resulted in intensified wind
 19794 erosion and dust storms.

19795 (6) Use of protected areas for waste storage/ dumping.

19796 In addition, much of the institutional framework underpinning protected area governance and management in
 19797 the annexed areas has been lost, and many employees have resigned. The war has also indirectly led to major
 19798 reductions in national budgets for protected areas, both within and outside of the conflict zone (Melen'-
 19799 Zabramna et al., 2015).

19800 **End of Box 4.4**

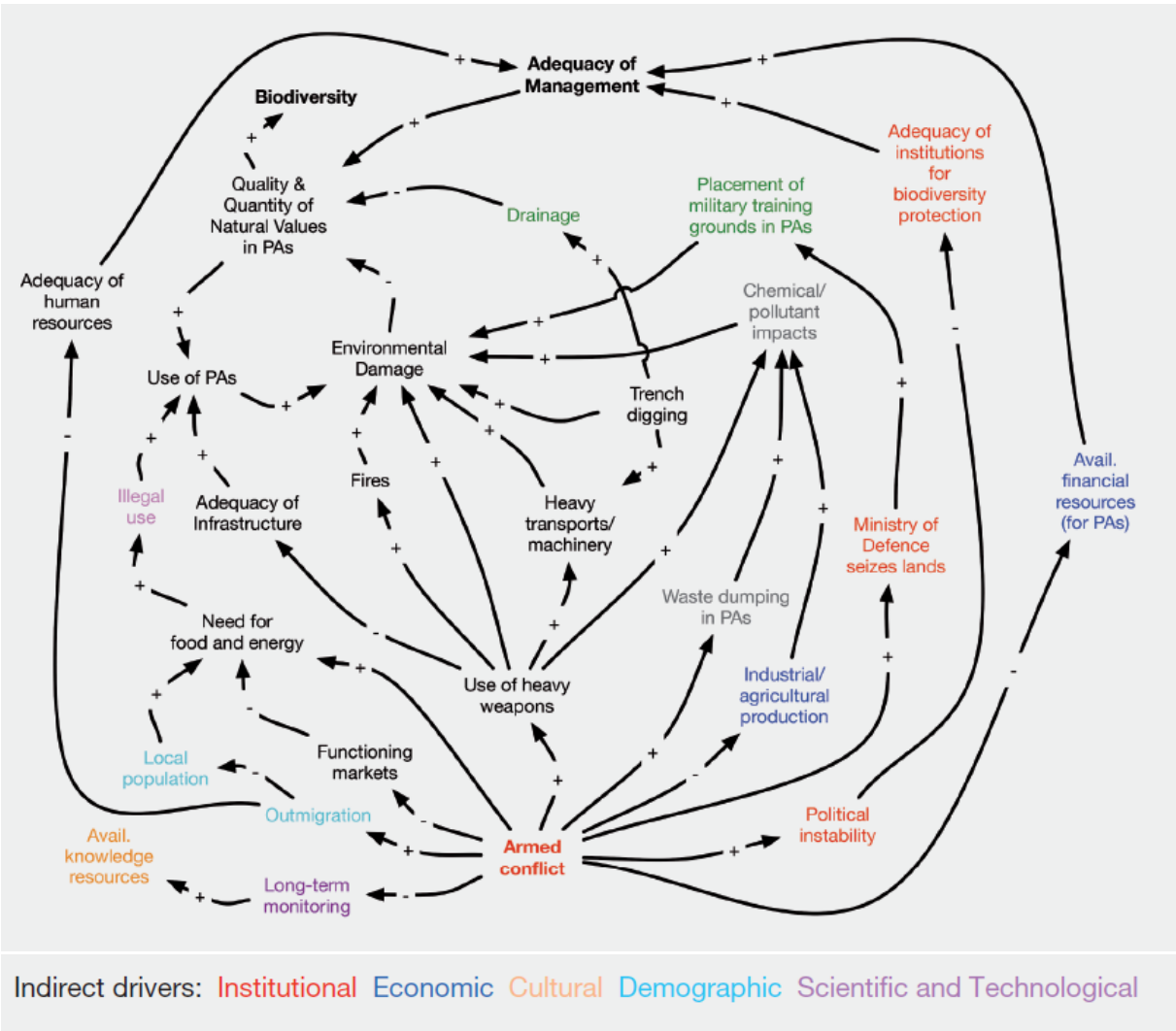


Figure 4.36: Armed conflict has many deleterious effects on protected areas, including multiple direct and indirect environmental impacts, diversion of economic resources from protected area budgets, loss of institutions and human resources, and interruption of long-term monitoring (own illustration).

4.5.4.2.7 Landscape and habitat restoration

Landscape and habitat restoration offers opportunities for nature conservation and protected area development. For certain habitat types, restoration activities are prescribed to secure sufficient areas for protection and for meeting Aichi Biodiversity Target 11. High rates of land conversion, including loss of cultural landscape habitats dependent on traditional land use (Hartl & Pleininger, 2014) and the expansion of modern forestry into remnants of natural forests in the northern part of Western Europe (Naumov et al., 2017), implies the continued loss of high-quality areas suitable for protection. Lack of suitable areas combined with demands for efficient use of limited resources for protection leads to the consideration of sites/areas of lower natural values in terms of biodiversity and nature’s contributions to people. This includes, for example, expanding existing reserves with adjacent areas of lower conservation value, but providing long-term benefits by succession or active conservation (Mazziotta et al., 2016; Polasky et al., 2008) (Figure 4.38).

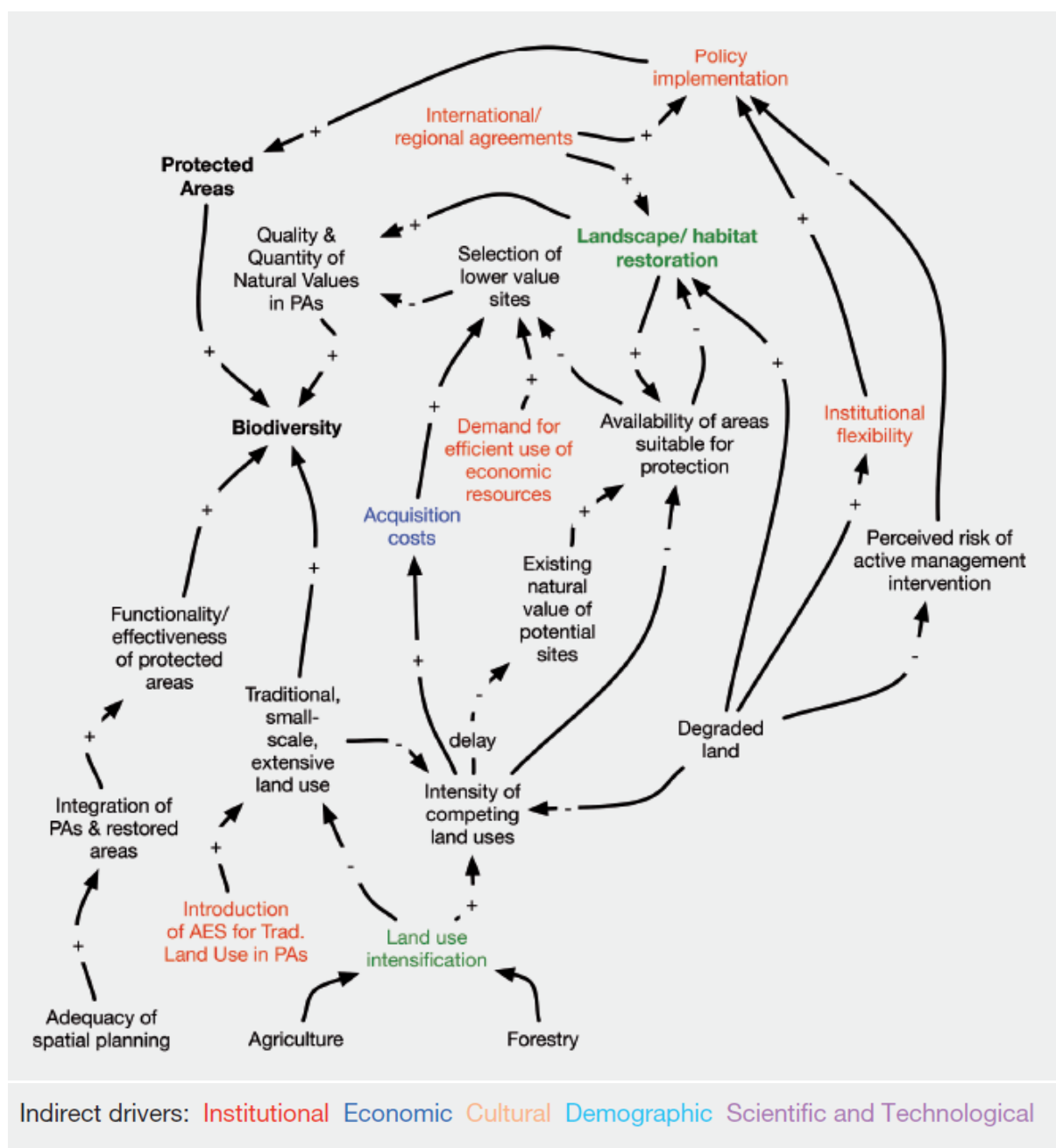


Figure 4.37: The restoration of degraded land can be an important opportunity for nature protection in some regions, particularly where land prices are high or land uses are intensive (own illustration).

The restoration of degraded land is a part of the Strategic Plan for Biodiversity 2011-2020 (specifically Aichi Biodiversity Target 15 – “ecosystems restored and resilience enhanced”) and is included in the European Union’s biodiversity strategy; both calling for restoration of at least 15% of degraded ecosystems. Degraded lands may offer multiple opportunities for restoration projects, including lower land prices, fewer current users and greater support for active management interventions, lower perceived risks, and greater institutional flexibility (Dawson, Elbakidze, Angelstam, & Gordon, 2017).

4.5.4.2.8 Tourism

Tourism opportunities can provide a political incentive for protected area establishment, due to the possibility of offsetting protection costs with sought-after rural socio-economic development

(Sevastiyanov, Colpaert, Korostelyov, Mulyava, & Shitova, 2014; Svoronou & Holden, 2005; Zachrisson, Sandell, Fredman, & Eckerberg, 2006). An example is the creation of new diving tourism opportunities associated with marine protected areas. However, the introduction of new user restrictions for local residents, while at the same time opening up the area for new users (tourists), may reinforce insider-outsider dynamics or otherwise engender local resistance and conflicts (Colchester, 1997; Cortes-Vazquez, 2014). For example, a number of studies note that urban populations tend to adopt a more dualistic perspective regarding human-nature relations, supporting calls for more protected areas with less human intervention in their management (Coleman & Aykroyd, 2009; Cortes-Vazquez, 2014; John D. C. Linnell, Kaczensky, Wotschikowsky, Lescureux, & Boitani, 2015). Additionally, the transition from a staple economy to jobs based on amenity values, outdoor recreation and tourism can also be challenging for many local rural communities (Westlund & Kobayashi, 2013). Recent legislative amendments in Russia (see above) have opened protected areas up for tourism, ostensibly as a means to improve their economic situation (Борейко, Бриних, & Парникоза, 2015; Чибилёв, 2014; Штильмарк, 2014). The engagement of strict nature reserves, for example, in commercial activities (primarily tourism) has led to numerous attempts to violate the nature protection regimes in both federal and regional protected areas, and UNESCO World Heritage sites, including illegal construction of tourism-related infrastructure (Степаницкий & Крейндин, 2004) (Figure 4.39).

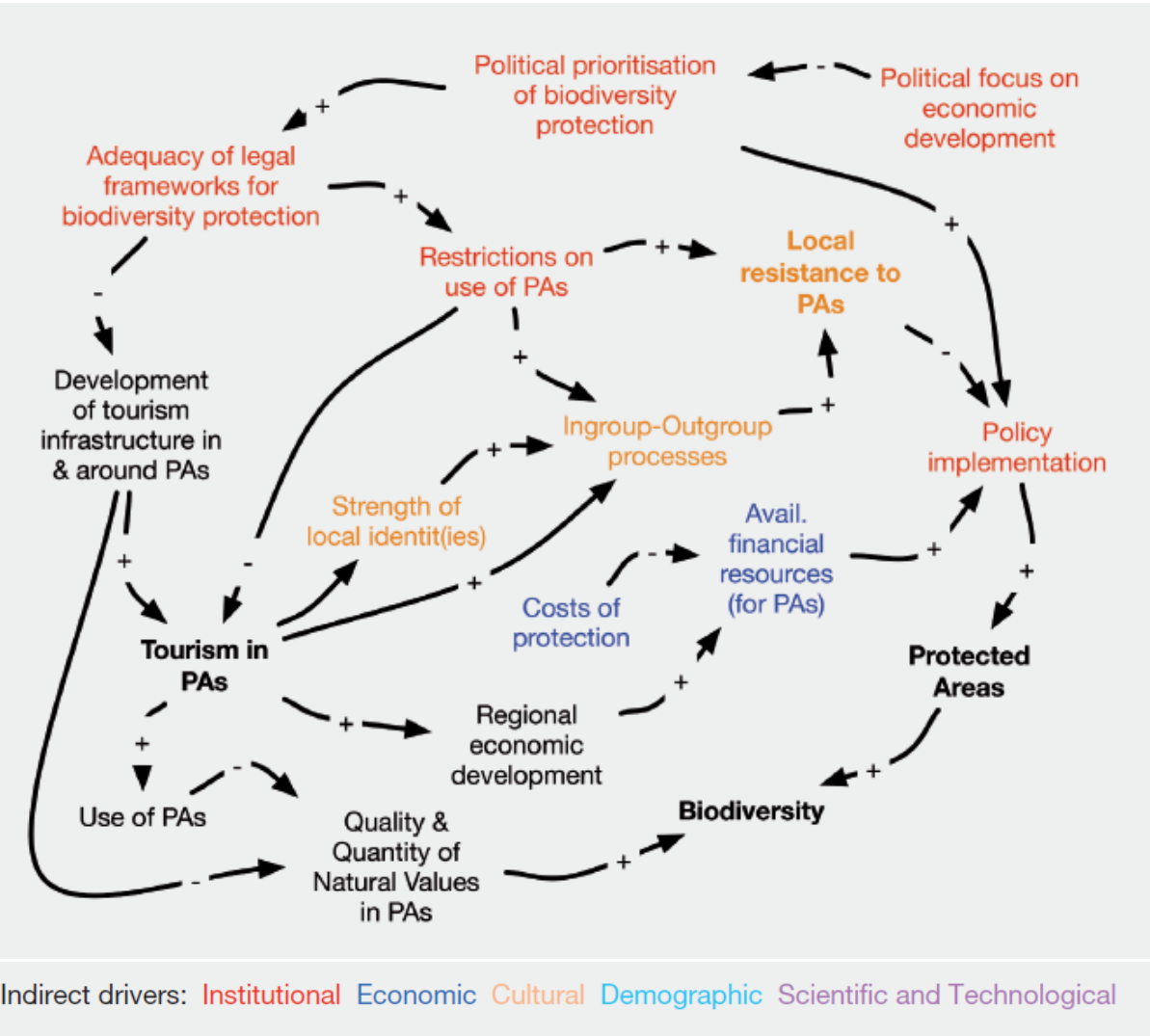


Figure 4.38: Tourism offers opportunities for regional economic development offsetting some of the costs of protected areas (own illustration). However, tourism and related infrastructure have

negative impacts on the natural values under protection, as well as encouraging the erosion of protection policies. Encouraging tourist use while imposing restrictions on local use can result in conflicts.

4.5.5 Trends and indirect drivers of changes in traditional land use

4.5.5.1 Trends in traditional land use

Traditional land use encompasses multiple non-intensive, locally adapted land-use practices based on local and indigenous knowledge that have played a significant role in the development of diverse, productive and sustainable food and material production systems (Molnár & Berkes, 2017; J. A. Parrotta & Sunderland, 2015; J. Parrotta, Yeo-Chang, & Camacho, 2016; Tobias Plieninger, Höchtl, & Spek, 2006). In Europe and Central Asia, traditional land-use practices, including forest management, agricultural activities, and agroforestry, have influenced nature over millennia, leading to the development of diverse ecosystems and cultural landscapes favouring a range of semi-natural and natural habitats and associated plant and animal species (Aitpaeva, Egemberdieva, & Toktogulova, 2007; Fedorova, 1986; Kile, 1997; Laletin, 1999; O Saastamoinen, 1999; Olli Saastamoinen, Kangas, & Aho, 2000; Taksami & Kosarev, 1986; Turnhout, Bloomfield, Hulme, Vogel, & Wynne, 2012; Дмитриев, B., 1991) (Figure 4.40).



Figure 4.39: The traditional village system found in Eastern Europe’s forest and woodland landscapes is characterized by a centre-periphery zoning from houses, gardens, fields, mowed and grazed grasslands to forests (i.e. the ancient system with domus, hortus, ager, saltus and silva), as illustrated in this view of the village Volosyanka in the Skole district of Ukraine’s west Carpathian Mountains. Beginning in the left part of the picture, the church in the very village centre is surrounded by houses that are located in the bottom of the shallow valley. The private gardens have many fruit trees and

19879 shrubs. Further to the right there is a fine-grained mixture of grasslands, some individual fields of
 19880 which some have been mowed and have hay-stacks and some not yet, and fields, like the potato
 19881 field in the foreground. Further, to the right there is forest, which is grazed by cattle moving in and
 19882 out along specially designed fenced trails from the farm houses in the valley bottom. In addition,
 19883 above the tree line on the top of the mountains, there are open grazed pasture commons (Photo –
 19884 Per Angelstam).

19885 Since the 1950s, agricultural practices across the region and traditional land use have undergone
 19886 substantial changes (EEA, 2015; Van Zanten et al., 2014). There are two main trends in traditional land-
 19887 use systems in Europe and Central Asia: (1) substantial decrease in land area with traditional land use
 19888 and loss of traditional ecological knowledge; and (2) maintenance of traditional practices and
 19889 adaptation of traditional ecological knowledge to new ecological and socio-economic conditions.

19890

19891 Trend 1: Substantial decrease in land area with traditional land use and loss of traditional ecological
 19892 knowledge

19893 The land area, where traditional practices are still applied has substantially decreased in many regions
 19894 of Europe and Central Asia (Rotherham, 2007) as a result of socio-economical changes and land-use
 19895 intensification. However, many practices have survived on marginal lands, in protected areas, or as a
 19896 result of socio-cultural preferences (Juler, 2014; Lieskovský et al., 2014; Zsolt Molnár et al., 2016). For
 19897 example, transhumant herding, once dominant practice in most mountainous areas in Western and
 19898 Central Europe, has undergone a sharp decline but has still survived some regions due to cultural
 19899 traditions (e.g. in Romania, Juler, 2014) or as a part of organic farming activities (E. E. Evans, 1940;
 19900 Juler, 2014; Thompson, Price, & Galbraith, 2006). Other, more sedentary forms of herded grazing have
 19901 for example survived in the vast steppe areas of Hungary (Kis et al., 2016; Zsolt Molnár, 2014).
 19902 Traditional agro-silvicultural systems, including wood-pastures and coppicing, have almost completely
 19903 disappeared in Western and Central Europe, as well as management of forest commons according to
 19904 ancient regulations (Keith Kirby & Watkins, 2015; Rigueiro-Rodríguez A., Fernández-Núñez E.,
 19905 González-Hernández P., McAdam J.H., 2009). Traditionally managed wood-pastures have partly been
 19906 preserved in Romania (Tibor Hartel, Plieninger, & Varga, 2015), but are also in decline. For example,
 19907 traditional multi-species fruit orchards with ancient varieties and a species-rich semi-natural grazed
 19908 herb layer are also in decline, but have begun to revive over the past two decades in Romania (Antofie,
 19909 Barbu, Sand, & Blaj, 2016). Semi-natural grassland ecosystems in Western, Central and Eastern Europe
 19910 have been largely converted to agricultural fields, afforested or abandoned, depending on the region,
 19911 though agri-environmental schemes of the European Union may help some to survive. For example,
 19912 mountain meadows in the Carpathians (examples of the most species rich grasslands on Earth) are
 19913 mostly abandoned (Dániel Babai et al., 2015; Dengler et al., 2014; Ivaşcu, Öllerer, & Rákossy, 2016) (**Box**
 19914 **4.5**). In Estonia, traditionally managed semi-natural grassland habitats (wooded meadows, coastal
 19915 grasslands, floodplain meadows, dry and mesic grasslands) covered about 1.5 million hectares (35% of
 19916 the country) in 1950s (Kukk & Kull, 1997). Since then, some areas have been turned into cultivated
 19917 land but most overgrew with forest following the abandonment. By 2010, only 60'000 hectares of
 19918 semi-natural habitats (4% of their coverage in 1950s) remained, of which only 30'000 ha was under
 19919 appropriate management. However, the area under management has been increasing in past decades
 19920 with the help of targeted subsidies (Management Plan for Estonian Semi-natural habitats 2014-2020).

19921 Trend 2: Maintenance of traditional practices and adaptation of traditional ecological knowledge to
 19922 new ecological and socioeconomic conditions

19923 The essence of traditional practices and traditional ecological knowledge has been preserved or
 19924 adapted with new ecological and socioeconomic conditions in many marginal areas (e.g. mountains,

dry areas, taiga-tundra) across Europe and Central Asia. For example, in Eastern Europe, land-use systems based on beliefs, customs, norms, bans, and rules of natural resource use are maintained by numerous indigenous and local communities (Kile, 1997; Taksami & Kosarev, 1986; Turaev, Sulyandziga, Sulyandziga, & Bocharnikov, 2005). In a survey of more than 500 respondents from Central Siberia Vladyshevskiy et al. (2000) have shown that in the last years of the twentieth century the use of wild mushrooms and Siberian pine nuts increased from two- to threefold; the use of wild onion three- to fivefold; and berries one and a half to two times. In forest depending communities, non-timber forest products are often the main source of food and income for village populations, representing as much as 30–40% of family income (Laletin, Vladyshevskiy, & Vladyshevskiy, 2002).

Box 4.5: Nature is becoming wild – local perceptions of loss of traditional land use and its drivers in European cultural landscapes.



If traditionally managed hay meadows are abandoned, pioneer forests develop. Forced abandonment in national parks is often a source of conflict between locals and conservationists. In the case of the eastern Carpathians, however, both of them prefer the managed cultural landscape which is "in order" (left figure) according to locals and rich in species according to conservationists. Photo: Ábel Molnár.

Traditional small-scale farmers developed fine-scale multifunctional cultural landscapes all over Europe (Agnoletti, 2006). With global changes, cultural landscapes are often abandoned or transformed into urban or more intensively managed agricultural areas. If abandoned, natural processes may accelerate, native shrubs and trees and invasive alien species may spread. Local farmers often perceive these changes as a landscape-in-order where "each corner had a role" is changing into a landscape-in-disorder. Independently whether succession is going through more and more natural or degraded stages, locals perceive the process as "getting wild" meaning the intensity of ecosystem service use decreases (Dániel Babai & Molnár, 2014; Zsolt Molnár, 2014). Wild place is a specific folk habitat: under this expression local people understand an area with no or little human utilization. Wild places are e.g. narrow steep valleys where no livestock can graze and timber is difficult to get out, or marshes dominated by tall tussock sedges, which are difficult to cross, impossible to cut for hay and where livestock can drown (Dániel Babai & Molnár, 2014; Kis et al., 2016; Zsolt Molnár, 2014). Abandoned pastures with accumulating litter and encroaching shrubs also are areas that turn into wild. National parks manage their lands in many different ways to help protected species and natural regeneration. If cultural landscapes in national parks are managed in a way where agricultural use is abandoned, local people often argue: the park manages the landscape improperly by letting it turn wild (Bérard et al., 2005). These differences in understandings of "proper" landscape management may cause conflicts between authorities and locals (D. Babai et al., 2016; Kelemen et al., 2013).

End of Box 4.5

19959 Pastoralists in mountainous regions of Central Asia practice so-called vertical and horizontal migrations
 19960 (transhumant) of livestock (Alimaev et al., 2008; Kanchaev, Kerven, & Wright, 2003). Livestock mobility,
 19961 which is a main feature of traditional pastoralist patterns, is key for the sustainability of pasture
 19962 management (Galvin, Reid, Behnke, & Hobbs, 2008; S. Robinson et al., 2016). Traditional knowledge in
 19963 Central Asia has been widely used to control desertification and soil erosion in mountain areas. In
 19964 Tajikistan, where the use of stepped terraces has a 1,000-year history, planted forests are widely used
 19965 for stabilization of hill slopes (Anon, 2006). Methods for slope terracing and cultivation of fruit and nut
 19966 gardens, especially in the traditional system of land and water management known as boghara, has
 19967 been known to inhabitants of mountains since ancient times. Throughout the region, traditional
 19968 techniques including shelterbelts have been used to control windblown sands in the vicinity of
 19969 settlements.

19970 In the forest regions of the Caucasus, where pastures and haymaking resources are limited, local
 19971 people use a traditional “pasture turnover” system for regulated forest grazing. The creation of cultural
 19972 pastures in open areas within forests increases animal productivity while preventing damage to
 19973 sprouts and seedlings of valuable species (i.e., oak, ash, maple, beech) due to grazing in young,
 19974 naturally regenerating forest stands. Once regenerating trees attain heights sufficient to prevent their
 19975 damage by livestock, these forests are used on a temporary basis for grazing, while previously used
 19976 pastures are managed to encourage restoration of forest cover and growth of valued tree species
 19977 through natural regeneration (Eganov, 1967).

19978 Sacred sites are common throughout Europe and Central Asia where indigenous and local communities
 19979 still thrive (Bocharnikov et al., 2012). Such sites may range in size from small groves or even individual
 19980 trees to extensive forested landscapes. Some areas are considered sacred because they provide major
 19981 habitats for species with ritual or medicinal values. The protection of such sites is important for the
 19982 health and spiritual well-being of local communities (Samakov & Berkes, 2016). Protection of forest
 19983 resources based on religious beliefs is characteristic for Central Asia, where the sacralization of nature
 19984 is expressed in cultural traditions and practices connected with particular species and sites (Aitpaeva
 19985 et al., 2007).

19986

19987 *4.5.5.2 Drivers of trends in traditional land use*

19988 Multiple drivers have underpinned traditional land-use change across Europe and Central Asia. These
 19989 drivers are mainly context specific and differ across the region (**Figure 4.41**).

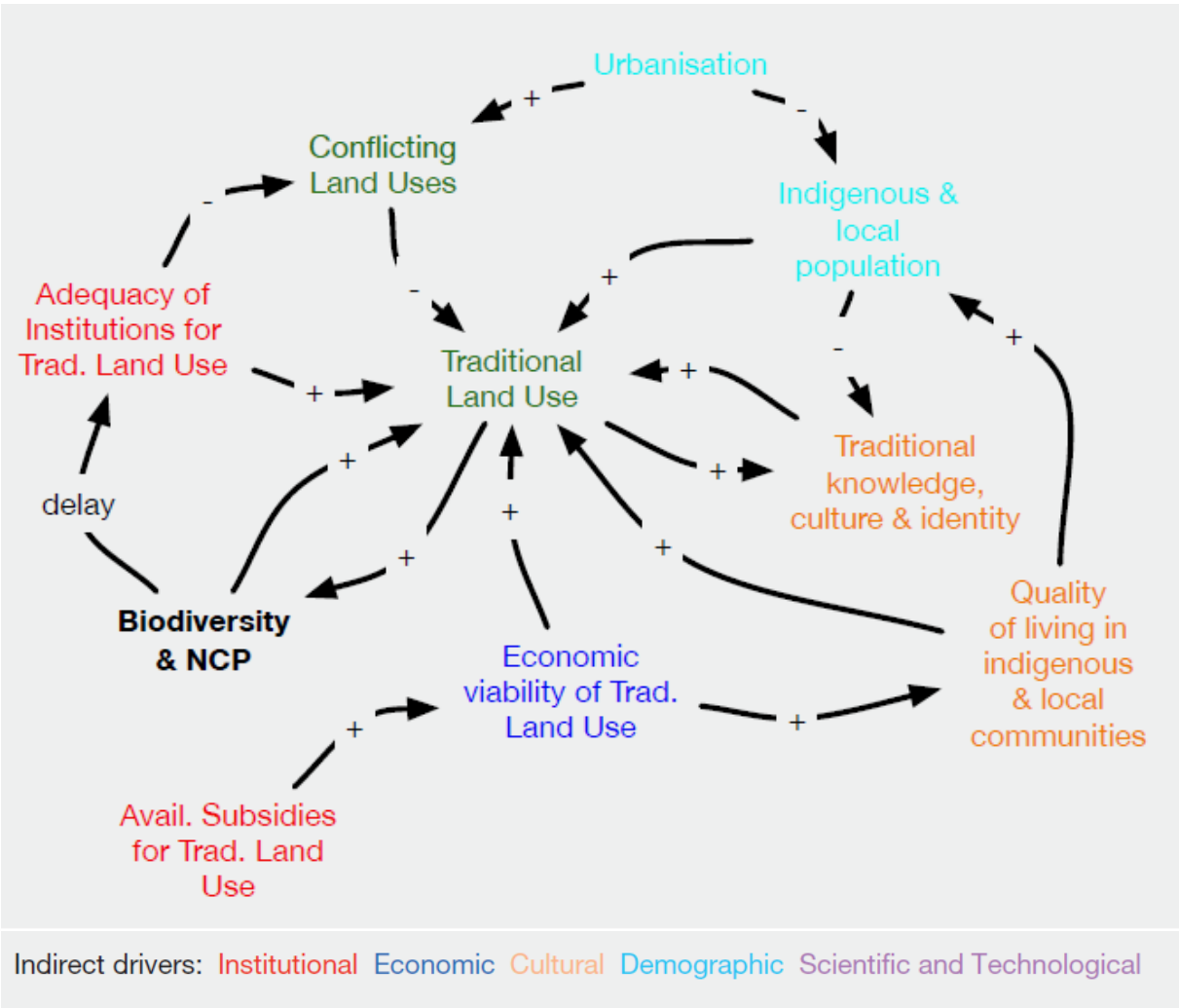


Figure 4.40: Institutional adequacy and economic viability are key drivers of traditional land use in Europe and Central Asia (own illustration). Demographic trends, including urbanization, continue to diminish indigenous and local populations, with concomitant negative impacts on traditional knowledge, culture and identities. These inter-relationships are further unpacked in a series of sub-models below (Figure 4.42 and Figure 4.43).

4.5.5.2.1 Institutional drivers of trends in traditional land use

In Central Europe, the European Union’s agricultural subsidies have a positive effect on grassland management; many areas abandoned in the 1990s (after collapse/dis-integration of the Soviet Union) are now grazed, mown and cleared of shrubs. In marginalized villages of Central Europe agri-environmental payments are a vital source of income for farmer families. However, culturally and ecologically less adapted regulations for traditional management have diverse side effects – hay meadows are turned into sheep pastures (Csérge et al., 2013), or old trees are cut on wood-pastures (T. Hartel & Plieninger, 2014). Revival of folk traditions among the youth in cities (e.g. folk singing, folk dancing) may provide a background for the maintenance of traditional practices in rural areas. Back-to-the-country movements are, however, hindered by ecologically and culturally inappropriate regulations (Dániel Babai et al., 2015). Recognition of and respect for viable and useful traditional management practices is vital, otherwise farmers may be reluctant to maintain or reintroduce them in their everyday management (Sereke et al., 2016) (Figure 4.42).

In Eastern Europe and Central Asia traditional land use has been especially affected by radical changes in the political system. In recent years, the indigenous peoples of Russia have been trying to restore their traditional livelihoods through legal efforts. The Russian Constitution contains the concept of “indigenous minorities”, whose rights are ‘guaranteed by the Russian Federation in accordance with the generally acknowledged principles and norms of international rights and international agreements. The Russian legislation ensures a new status for indigenous peoples by providing enabling conditions for traditional nature resource use within the so-called Territories of Traditional Nature Resource Use for indigenous peoples. These territories are designated to ensure environmental protection and to support indigenous livelihoods, religion, and culture. The legal norms for these territories are related to the various natural resource uses, such as reindeer breeding, hunting, fishing, and non-timber forest product collection, within different territories (Sulyandziga & Bocharnikov, 2006). However, there are no norms ensuring the preservation and use of traditional knowledge, especially in the management of traditional natural resources. During the preparation of the Strategy and Executive Plan for the Conservation of Biodiversity within the Russian Federation the new goal was formulated to ensure the maintenance of traditional lifestyles and the sustainable use of biodiversity by indigenous peoples, including consideration of traditional knowledge in the planning and implementation of activities related to use of biological resources (Ministry of Natural Resources and Environment of the Russian Federation, 2014). In Central Asia, a shift from state command-and-control economy to market-based economy led to the concentration of a large number of livestock in few hands, which left the majority of households in possession of small numbers of animals (S. Robinson et al., 2016; Vanselow, Kraudzun, & Samimi, 2012). To make the use of migratory routes economically viable, the households with a small number of animals revived the traditional models of pooling animals from many households and shepherding them on a rotational basis or hiring a shepherd among themselves (S. Robinson et al., 2016). As livestock numbers have started to recover following the hardship of early independence years, pasture management issues are becoming more urgent. Having recognized the value of traditional migratory grazing patterns and importance of livestock mobility in sustainable use of pastures, for example, countries in Central Asia have designated pastures as common property, and management of common pastures is exercised by a locally elected pasture users committee.

4.5.5.2.2 Economic drivers of trends in traditional land use

In Western Europe, the traditional practice of collecting non-timber forest products for wild food and medicine has been declining due to emigration to urban areas to pursue economic opportunities, to mass production of food and to modern synthetically produced medicines (Łuczaj et al., 2012; Quave, Pardo-de-Santayana, & Pieroni, 2012; Schulp, Thuiller, & Verburg, 2014). In some places, however, there are markets for wild plants and mushrooms (Richards & Saastamoinen, 2010; Sitta & Floriani, 2008). For these products, a market demand and viable industry exists, although affected by variation in harvests from year-to-year and sensitive to labour costs. Some of these markets are also dominated by imports (e.g. the Italian market of *Boletus*; Sitta & Floriani (2008)). Estimates of the value of non-timber forest products indicate that these may be in the same order of magnitude as traditional timber products. For instance, if forest management would take bilberry production into account in Finnish forests the economic gain during the rotation period could, theoretically, more than double (Miina, Pukkala, & Kurttila, 2016). It has also been shown that urban citizens demand a market for non-timber forest products and there can be a considerable demand for such products among urban consumers. This especially concerns food where quality and environmental friendliness is seen as important attributes (Kilchling, Hansmann, & Seeland, 2009) (**Figure 4.43**).

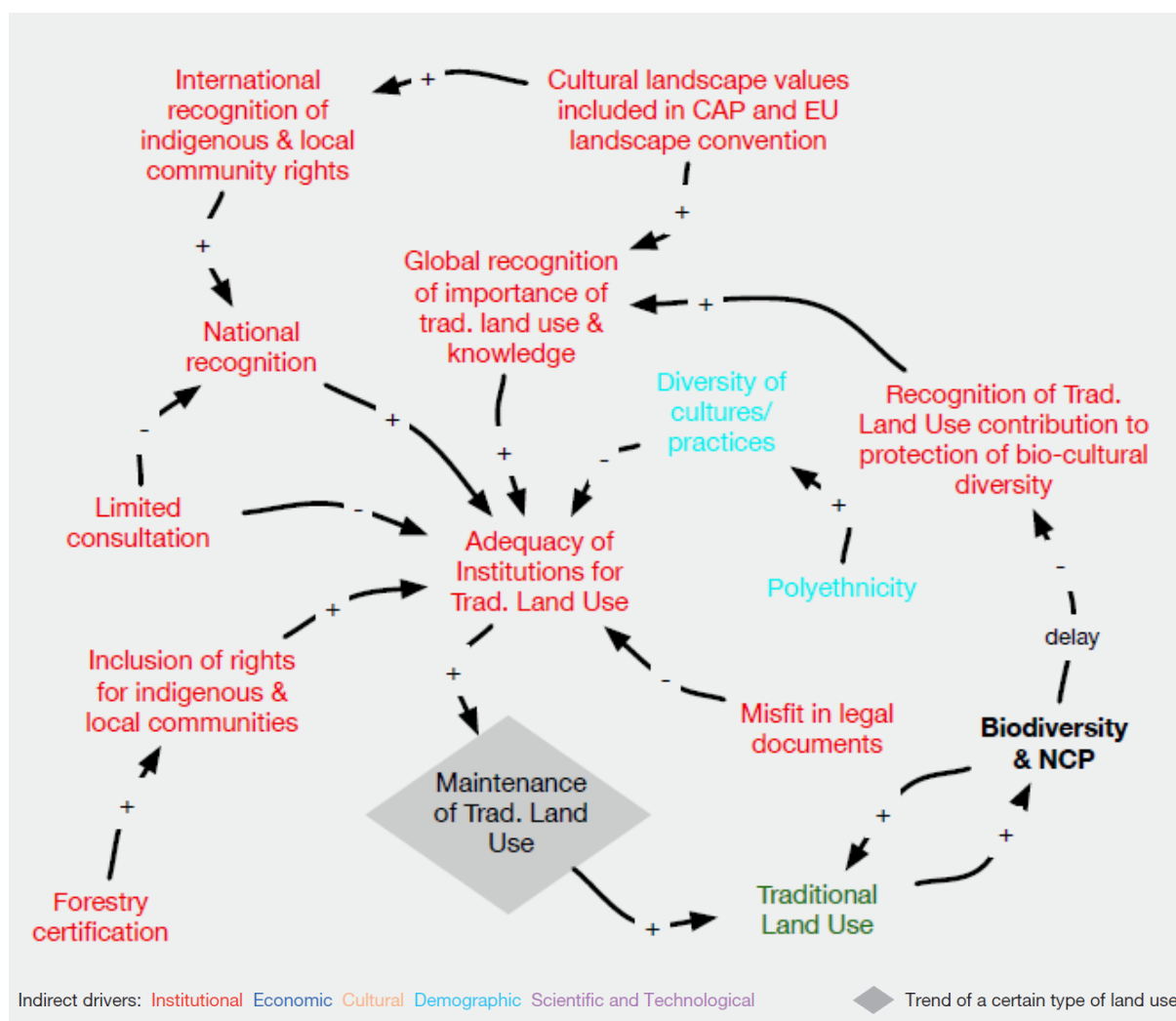


Figure 4.41: Growing international recognition of the rights of indigenous and local communities, and of the contribution of traditional land-use practices in protecting bio-cultural diversity, have improved a number of institutions concerning traditional land use in Europe and Central Asia (own illustration). Certification schemes have led to greater inclusion of indigenous and local rights in forest management systems. Poly-ethnic regions, with a broader diversity of cultures and practices to account for, face additional challenges in developing adequate institutions for traditional land use.

In the Russian Federation among the economic drivers that negatively affect the traditional land use of indigenous people is reduction of areas of traditional indigenous settlements due to industrial development. The Committee on the Affairs of the Indigenous Peoples of the Russian Federation in the materials for the Parliamentary hearings on Legal provision of technological expertise (2007) stated “From the 1930s the structure of nature resource use and the concept of development of the North gave priority to industrial development instead of the traditional land use, which resulted in severe pollution and degradation of the natural environment that led to the disruption and retirement of the most valuable agriculture land. First of all, significant damage was done to reindeer pastures. One factor that destabilizes the ecological situation in the area of traditional land use is stressful influence of industrial facilities on deer pastures and hunting grounds, covering up to 40% of the area of ‘traditional land use’. Due to industrial development and pollution by industrial emissions of the traditional land-use area, the rural population lost not only pastures and hunting grounds, but also

traditional fishing areas and areas for gathering wild plants” (“Доклад о развитии человеческого потенциала в Российской Федерации,” n.d.).

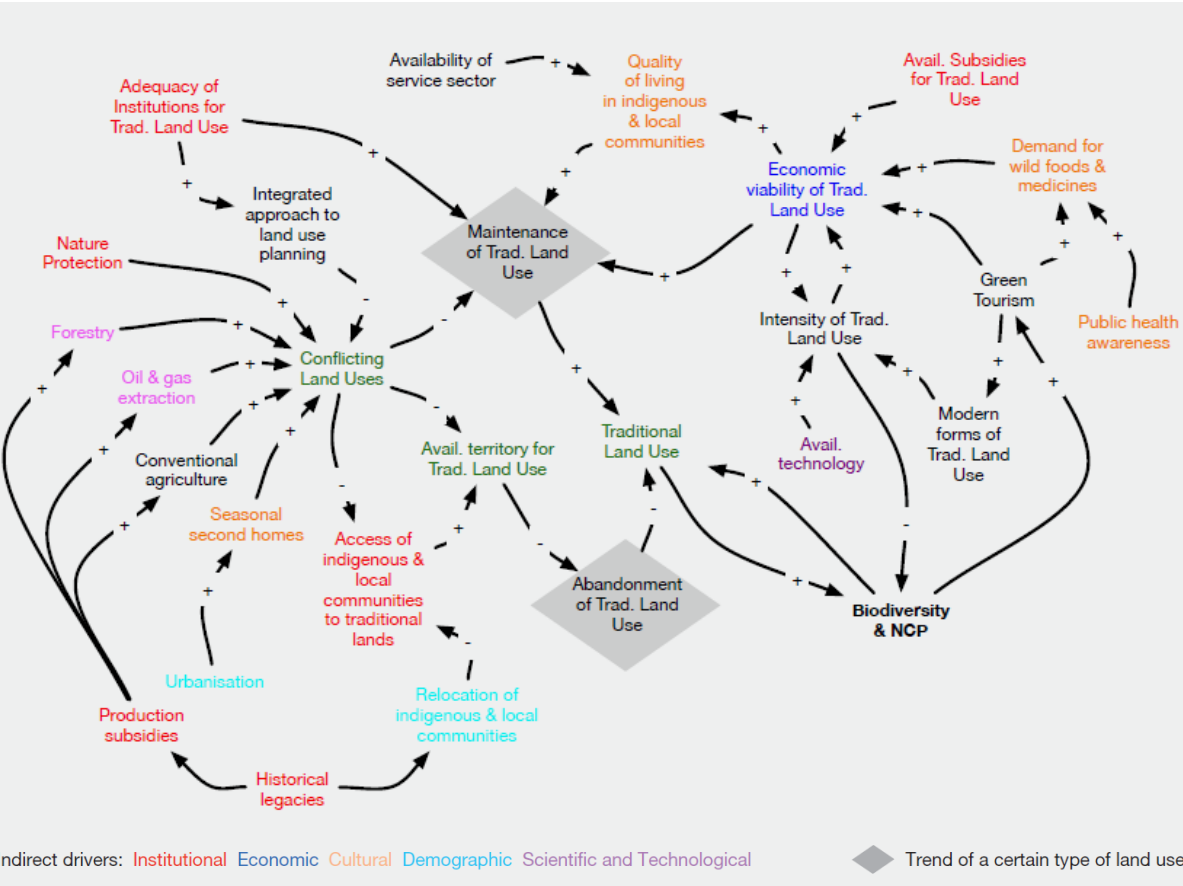


Figure 4.42: Production-based subsidies driving growth in agricultural, forestry and natural resource extraction sectors tend to exacerbate conflicting land-use issues, often impinging on available territory for traditional users (own illustration). Maintenance of traditional land use is dependent on the quality of living that traditional lifestyles afford to indigenous and local communities, in turn dependent on the economic viability of traditional land-use practices and the availability of services. The growth of green tourism and demand for products derived from traditional practices, the modernization of practices, and the availability of subsidies for traditional land-use practices are important factors in ensuring the economic viability of traditional practices.

4.5.5.2.3 Social drivers of trends in traditional land use

Often, people leave rural areas for higher education and higher salaries in cities. Even people living in villages pursue an urban lifestyle. In Western Europe, the last few decades’ health industry development and alarm about unhealthy additives in mass-produced food have resulted in a renewed interest in wild food and medicine (Mabey, 2001; Reynolds Whyte, van der Geest, & Hardon, 2002). Wild food is considered pure, naturally healthy and rich in vitamins and antioxidants (Łuczaj et al., 2013). Moreover, wild plants and mushrooms play an important role as spices and accompaniments in traditional cuisines in the region (Łuczaj et al., 2013; Sõukand et al., 2013; Stryamets, Elbakidze, Ceuterick, Angelstam, & Axelsson, 2015; Svanberg, 2012). There is also a growing interest in folk medicine in different parts of the region (DuBois & Lang, 2013; Ghirardini et al., 2007; González-Tejero et al., 2008; Łuczaj et al., 2013; Vitalini, Tomè, & Fico, 2009), even where collecting plants for medicinal

purposes is no longer a widespread practice (Łuczaj et al., 2012; Molina, Reyes-García, & Pardo-de-Santayana, 2009; Quave et al., 2012; Rigat, Bonet, Garcia, Garnatje, & Vallès, 2007).

4.5.6 Trends in urban development

Urban populations are foreseen to increase considerably across Europe and Central Asia (United Nations, 2014), which may cause further urban sprawl, depending on urban planning policies. In Europe, urban sprawl has increased considerably over the past decades. Between 2006 and 2012, semi-natural and natural areas were converted into artificial surfaces at a rate of 107,000 ha/year in 39 European countries (EEA, 2016c). Urban land expansion has mostly taken previous arable areas and, to a lesser extent, semi-natural habitats and forests (EEA, 2016c). In Central Asia, the rate of urban sprawl was reduced following independence of its constituent States. This was because of economic reasons, but also because migration from rural areas to urban areas increased the density of urban populations rather than the expansion of urban areas (Osepashvili, 2006). Unusually, Kazakhstan experienced a decline in urban populations coupled with increases in the rural population between 1990 and 2014 (United Nations, 2014). A further example of urban sprawl is growing migration to coastal areas, especially in the Mediterranean in Western and Central Europe (**Box 4.6**).

Box 4.6: Urban sprawl on the Mediterranean coast

Human pressures on the Mediterranean coast are further exacerbated by urbanization, resulting in the decline of rural areas (Giacanelli, Guarino, Menegoni, & Pignatti, 2015; C. Kelly et al., 2015). The general result is a spatial dichotomy between strong, heavily populated coastal areas and thinly populated inland areas, with lower urban density and a less dynamic economy (Parcerisas et al., 2012). The Mediterranean coasts also host a large seasonal tourist population and, even if the fortunes of Mediterranean destinations have fluctuated in recent years, the whole region remains among the most popular destinations of the global tourist market (UNWTO, 2015). Tourism is the main source of foreign income in the Mediterranean region, representing as much as 25% of GDP in some countries (WTTC, 2015). Projected tourist arrivals in the Mediterranean basin for 2030 are estimated as 350 million (WWF, 2004). The environmental impacts of tourism are far-ranging and include land-use changes, pollution and waste production. Both resident and seasonal human populations are dependent on the availability of resources, infrastructures and services. These economic and demographic shifts also brought radical changes in agricultural, industrial and commercial sectors, all with their own share of environmental implications, ranging from soil degradation (Guerra, Metzger, Maes, & Pinto-Correia, 2015), land abandonment (Reino et al., 2010), habitat loss (Monteiro, Fava, Hiltbrunner, Della Marianna, & Bocchi, 2011), waste production and disposal (Tatsi & Zouboulis, 2002), land-use changes (Celio, Koellner, & Grêt-Regamey, 2014; Serra, Pons, & Saurí, 2008) and pollution of water resources, both freshwater and marine (Zalidis, Stamatiadis, Takavakoglou, Eskridge, & Misopolinos, 2002). With the help of new technologies enabling the harvest of higher yields, many initially traditional livelihood activities, like subsistence fishing, turned into new, capital-driven economic sectors. Mediterranean fisheries are also the subject of political controversies due to territorial disputes and degradation of marine habitats (Hofrichter, 2003).

The impacts of people moving to the coast are both direct and indirect, with direct impacts including emissions of effluents and pollutants, and indirect impacts including locational factors, where urbanization and industrial areas often serve as hubs for further urban sprawl (Salvati, 2013). Maritime transport also presents a key environmental pressure, with several major commercial routes crossing the Mediterranean Sea. On average, there are about 60 maritime accidents in the Mediterranean annually, of which about 15 involve fuel or chemical spills (EEA, 1999).

Water is also becoming a scarce and valuable commodity in the Mediterranean region, either because of decreasing quantities or inadequate quality. Today it is evident that damming cannot be considered a long-term and large-scale solution to water shortage, while desalination with reverse osmosis technology requires vast amounts of energy (Teixeira, Teixeira, & Marques, 2014). The water conflict in the Middle East and North Africa

20148 already provided ample examples of the volatile nature of negotiations over water resources, particularly across
20149 national boundaries (Poff et al., 2003).

20150 Climate change will also play a major role in the future evolution of the Mediterranean Basin. Potential impacts
20151 related to climate change include drought, floods, sea level rise, changes in the marine currents, and increased
20152 storm frequency. All of these changes will affect most coastal regions, with likely repercussions on national
20153 economies, particularly where those are directly dependent on natural resources and tourism. The critical factor
20154 for implementing future strategies in the Mediterranean region is cooperation, as environmental threats are not
20155 constrained by national boundaries.

20156 **End of Box 4.6**

20157

20158 **4.6 Drivers and effects of pollution**

20159 By extracting resources and returning them to the environment as waste, humans alter the
20160 biogeochemical cycles that have evolved for millennia. Pollution arises when humans introduce new
20161 substances that are toxic to species, or when the rate at which humans generate and deposit waste is
20162 faster than nature's own rate of re-absorbing and effectively neutralizing these resources.

20163 Pollution is often categorized according to its effect in a certain medium i.e., air, water or soil/land. In
20164 this chapter, we categorize pollution according to pollutant or problem/effect (**Table 4.6**) and focus on
20165 five categories: nutrient pollution, organic pollution, acidification, xenochemical and heavy metal
20166 pollution and “other pollution” (i.e. ground-level (tropospheric) ozone, light and plastic pollution).
20167 Gene pollution, noise pollution, thermal pollution and radioactive pollution were also identified as
20168 relevant, but generally to a lesser extent, and are therefore not included in this assessment.
20169 Greenhouse gas emissions causing climate change and the introduction of invasive alien species can
20170 also be considered as pollution (Spangenberg, 2007; Weale, 1992) and have therefore been included
20171 in **Table 4.6**, which provides an overview of pollutants, problems/effects, and their drivers.

20172 **Table 4.6: Categorization of pollutants, problems/effects and main drivers. Source: authors**

Pollutants	Problem/Effect	Main drivers
Bio-accessible nitrogen and phosphorus in terrestrial, freshwater and marine ecosystems	Eutrophication (hypertrophication)	Agriculture, industrial air pollution, wastewater
Organic pollutants	Oxygen-depleted systems, eutrophication, soil erosion, brownification	Wastewater, land-use change
Sulphur dioxide and nitrogen oxides from high temperature energy release, ammonia	Acidification	Electricity production, agriculture, incineration and industrial processes, transportation
PBT, POPs, pesticides, PCBs, dioxins, furans, PAHs, heavy metals	Xenochemical and heavy metal pollution	As above plus mining, chemical production

Nitrogen oxides, volatile organic compounds including methane, carbon monoxide	Ground-level ozone	Electricity production, industry, transportation
Light pollution	Disruption of species reproduction and survival	Material intensity of GDP, low variable cost of LED
Plastic debris	Life of marine organisms	Polymer production
Carbon dioxide, nitrous oxide, methane, etc. (Section 4.7)	Climate change	Energy use and agriculture
Invasive alien species (Section 4.8)	Biological invasion, biodiversity loss	Globalization

20173

20174 Pollution is influenced by natural resource extraction. In turn, it also influences some forms of resource
 20175 extraction. For example, local fishing communities on the Faroe Islands, Denmark, who are pressed by
 20176 international opinions to stop killing pilot whales, are more worried that the whales are too polluted
 20177 to consume and that the whales will become extinct due to pollution (Nieminen et al., 2004).

20178

20179 4.6.1 Nutrient pollution

20180 Nutrient pollution arises when the concentrations of nutrients that are naturally found in low
 20181 concentrations, such as phosphorus (P) and nitrogen (N), increase to excessive levels. This also causes
 20182 eutrophication in freshwater and marine ecosystems. In Europe and Central Asia phosphorus is often
 20183 the main problem (nutrient which constrains eutrophication) in freshwater while nitrogen is most
 20184 often the limiting nutrient in terrestrial and marine environments.

20185

20186 4.6.1.1 Effects of nutrient pollution on biodiversity and nature's contributions to people

20187 Increased nitrogen concentrations enhance productivity through fertilization and they decrease
 20188 biodiversity through eutrophication and acidification (**Figure 4.44**). The deposition of reactive nitrogen
 20189 (nitrogen oxides (NO_x) and ammonia (NH₃)) reduces biodiversity in terrestrial ecosystems by favouring
 20190 plant species well adapted to nitrogenous or acidic conditions at the cost of less tolerant species
 20191 (Bobbink et al., 2010). Susceptibility to stress, such as frost damage or disease, may also be enhanced
 20192 (Dise et al., 2011). An annual deposition of 5–10 kg nitrogen per hectare has been estimated as a
 20193 general threshold for such adverse effects (Bobbink et al., 2010). The species richness of understory
 20194 vegetation of Western and Central European forests also decreased with increasing nitrogen
 20195 deposition rates and oligotrophic species were replaced by eutrophic ones (Dirnböck et al., 2014).

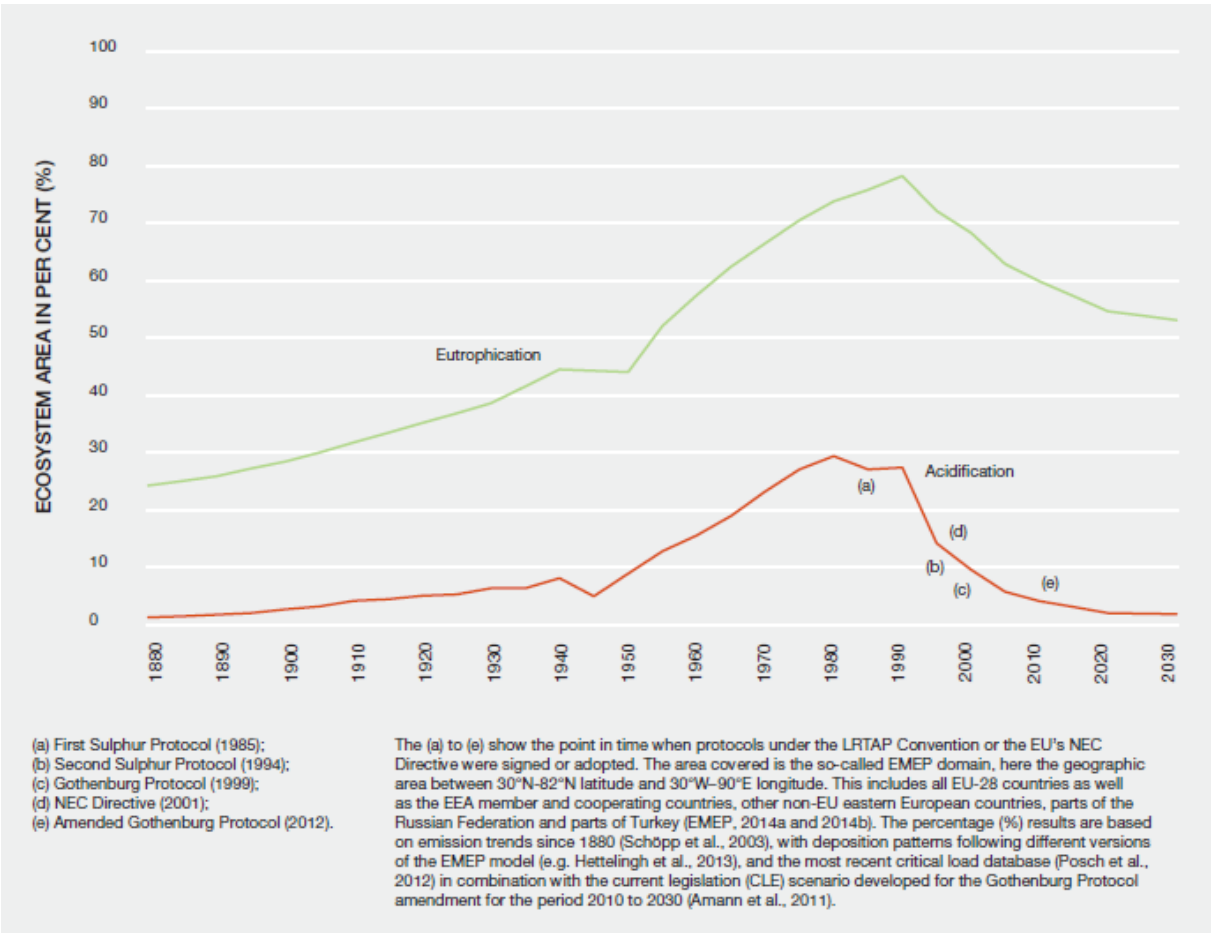


Figure 4.43: Acidification and eutrophication of terrestrial ecosystem in Western and Central Europe peaked in the 1980s and early 1990s and have been reduced in extent (area) since then. Source: EEA (2014a); EEA (2014b).

Eutrophication of marine ecosystems is perhaps more worrying than freshwater eutrophication since, although recent studies have shown a decrease in marine and coastal eutrophication, the number of marine dead zones due to hypoxia (oxygen depletion due to organic pollutants) fuelled by eutrophication has increased markedly (EEA, 2014a; EEA, 2014b) (Figure 4.45).



Figure 4.44: Eutrophication and hypoxia are very frequent in coastal areas in Europe and Central Asia (EEA, 2014d).

Emissions of nitrogen have contrasting implications on nature's contributions to people. There are clear and well-established negative impacts of nitrogen, derived from anthropogenic reactive nitrogen (NO_x and NH_3) on eutrophication, soil acidification, drinking water quality (Villanueva et al., 2014) and human health (World Health Organization, 2013). Besides, nitrous oxide (N_2O , a potent greenhouse gas, produced in soils with excess nitrogen, is increasingly emitted into the atmosphere, where it contributes to climate warming and, in the stratosphere, to the decomposition of ozone (Ravishankara, Daniel, & Portmann, 2009).

Increased nitrogen deposition, however, can positively influence other contributions of nature to people like crop, timber and livestock production (J. Wang et al., 2015). Carbon sequestration is higher in nitrogen-limited systems if nitrogen deposition increases (Erisman et al., 2014). In an evaluation of these opposing effects on nature's contributions to people, a reduction in nitrogen deposition was estimated to have net benefits to society by reducing the need for greenhouse gas regulation measures and by increasing non-material contributions, such as recreation. These benefits exceeded the total cost of material contributions (L. Jones et al., 2014).

Phosphorous has long been regarded as the main driver of eutrophication in freshwater ecosystems. Excessive levels of phosphorous and soil erosion (organic P) cause an overgrowth of plants and algae that in turn increases the level of activity of decomposers and decreases the dissolved oxygen levels (hypoxia). This affects biodiversity negatively, mainly invertebrates and higher plants (Lepori & Keck, 2012; Lyons et al., 2014; Nöges et al., 2016). The internal loading of phosphorous from sediments in lakes can keep them in a state of eutrophication even when external inputs are reduced, a process that is further promoted by increased temperatures (B. Moss et al., 2011). Such legacy effects, i.e. phosphorous accumulation in sediments, have recently been observed in the River Thames (UK) where algal blooms still occur in most years, controlled by light and water temperature (Bowes et al., 2016).

A meta-analysis found that phosphorous limitation of primary production is as strong as nitrogen limitation and is not confined to freshwater ecosystems and tropical forests as previously believed (Elser et al., 2007). A study of more than 500 unfertilized grasslands in five countries in Western Europe found a significant negative effect of soil phosphorous on plant species richness, mainly in acidic grasslands (Ceulemans et al., 2014). Species richness decreased until a threshold value (104-130 mg P/kg soil depending on grassland type), indicating that species loss is fastest at low phosphorous concentrations (**Figure 4.46**).

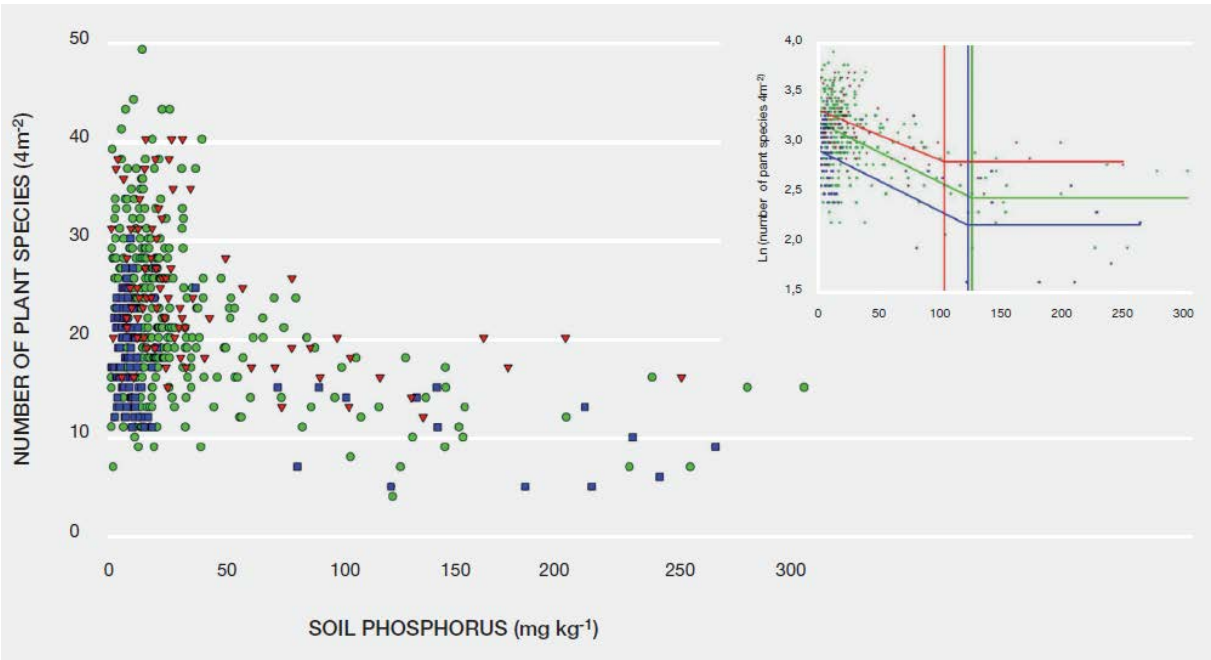


Figure 4.45: High soil (plant-available) phosphorous concentration negatively affects terrestrial plant species diversity (Ceulemans et al., 2014).

4.6.1.2 Trends in nutrient pollution

Between 1980 and 2011, NO_x and NH₃ emissions in the European Union declined by 49% and 18%, respectively (EEA, 2014b). 94 % of NH₃ emissions come from agriculture (EEA, 2016a). However, while NO_x continues to decrease, NH₃ emissions in Western Europe have stabilized with even slight increases in recent years (EEA, 2016a) (see also **Figure 4.49** under Acidification). For Western and Central Europe (EEA-39), NO_x emissions are projected to further decrease in future years while NH₃ emissions will stay approximately constant until 2020 (EEA, 2016a). Some uncertainty prevails, for example Turkey reported a doubling of NH₃ emissions between 2012 and 2013; the level was kept for 2014 (EEA, 2016a).

The average nitrogen deposition rate in the region is about 5 kg/ha/yr, in contrast to a background rate of 0.5 kg/ha/yr or less (BIP, 2016).

The anthropogenic input of phosphorous increased from <0.3 Tg/yr before the industrial revolution to 16 Tg/yr currently (Peñuelas, Sardans, Rivas-ubach, & Janssens, 2012). Over 50% of the soils studied in Belgium, Netherlands and Sweden had higher phosphorous levels than recommended (Ceulemans et al., 2014). In contrast, the levels of total-phosphorous decreased markedly in rivers and lakes, mainly due to advances in wastewater treatment (**Figure 4.47**).

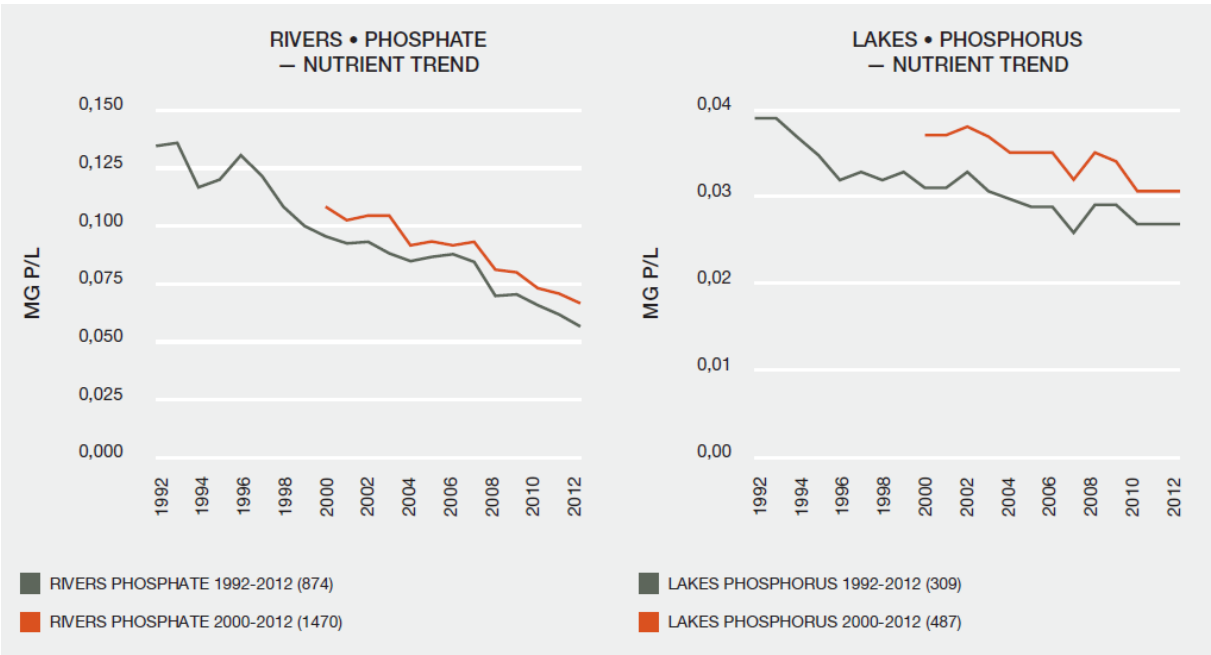


Figure 4.46: Changes in phosphorous concentrations in Western and Central Europe. Source: (EEA, 2015c).

There is little information on changes expected until 2050. However, phosphorous-limited terrestrial ecosystems have lately increased in extent and will continue to do so due to climate change (Peñuelas et al., 2012).

4.6.1.3 Drivers of nutrient pollution

In Western and Central Europe, nutrient pollution is driven by agricultural land-use change (intensification by increasing manure, fertilization and soil erosion), wastewater (sewage and septic systems), storm water, fossil fuel combustion in transportation and energy production (increasing NO_x), and households (gardens, detergents) (EEA, 2015c).

Regulations and technological innovation have been effective in reducing NO_x and, except in recent years, NH₃. These decreases are mainly due to policies that enforced measures in transportation (catalytic converters and fuel switching), plant improvement (e.g., flue-gas abatement techniques) in the energy and production industries, and the Nitrate Directive in agriculture reducing the use of fertilizer. The emissions of N₂O decreased by 38% mainly due to the measures of the European Union Nitrate Directive, the Common Agriculture Policy (CAP), and the Land-fill Waste Directive (EEA, 2014c).

Vegetarianism is a cultural driver with a high potential: a 50% reduction in the consumption of animal products would lead to at least a 10%-reduction in nitrogen pollution in the EU-27 (Van Grinsven, Erisman, De Vries, & Westhoek, 2015).

Climate change is expected to have adverse effects by increasing erosion and nutrient run-off in agricultural areas, frequency of wastewater overflow, water temperature, and the duration of the growing season (Dokulil & Teubner, 2010).

20282 4.6.2 Organic pollution

20283 Organic pollution refers to large emissions to water of organic compounds that can be oxidized by
 20284 naturally occurring micro-organisms. Organic pollution is most often point-source, i.e., released
 20285 directly into the water, although diffuse loss from catchments can also yield large amounts of organic
 20286 compounds. The most important sink of organic pollutants is decomposition by bacteria and fungi by
 20287 enzymatic catalysis. These decomposers grow rapidly and use a great deal of oxygen during their
 20288 growth. When they die, they are broken down by other decomposers, which causes further depletion
 20289 of the oxygen levels (hypoxia and eventually anoxia).

20290

20291 4.6.2.1 *Effects of organic pollution on biodiversity and nature's contributions to people*

20292 In freshwater, increased levels of easily degradable organic compounds reduce primary production
 20293 and degrade habitats for aquatic life (Couture, Charlet, Markelova, Madé, & Parsons, 2015). Easily
 20294 degradable organic compounds have a well-documented, strong negative impact on riverine
 20295 biodiversity by depleting oxygen to critically low levels for benthic macroinvertebrates and fish
 20296 (Connolly, Crossland, & Pearson, 2004; Hering, Feld, Moog, & Ofenböck, 2006; Sand-Jensen &
 20297 Pedersen, 2005). Organic compounds also increase light attenuation in the water column ("browning"
 20298 if the source is humic compounds) and the epiphytic growth of biofilm (Burns & Ryder, 2001;
 20299 Richardson, Beardall, & Raven, 1983).

20300 Organic compounds strongly bind various toxins, thereby somewhat reducing their bioavailability
 20301 (Ravichandran, 2004). They also serve as transport vectors for heavy metals and organic pollutants
 20302 (Kopáček, Hejzlar, Kaňa, Porcal, & Klementová, 2003), which are toxic for aquatic life (Ravichandran,
 20303 2004; Teien, Standring, & Salbu, 2006).

20304 The ecological status of Western and Central European rivers and lakes is strongly linked to pollution
 20305 by nitrogen, phosphorous and organic compounds (EEA, 2015c). Rivers with high concentrations of
 20306 nitrogen, phosphorous and organic compounds are more likely to be in a poorer ecological state. Lakes
 20307 with high nutrient loads will have high chlorophyll concentration and low water clarity due to abundant
 20308 phytoplankton growth. As a result, a large proportion of lakes and rivers in Western and Central Europe
 20309 do not reach a satisfying ecological status (**Figure 4.48**).

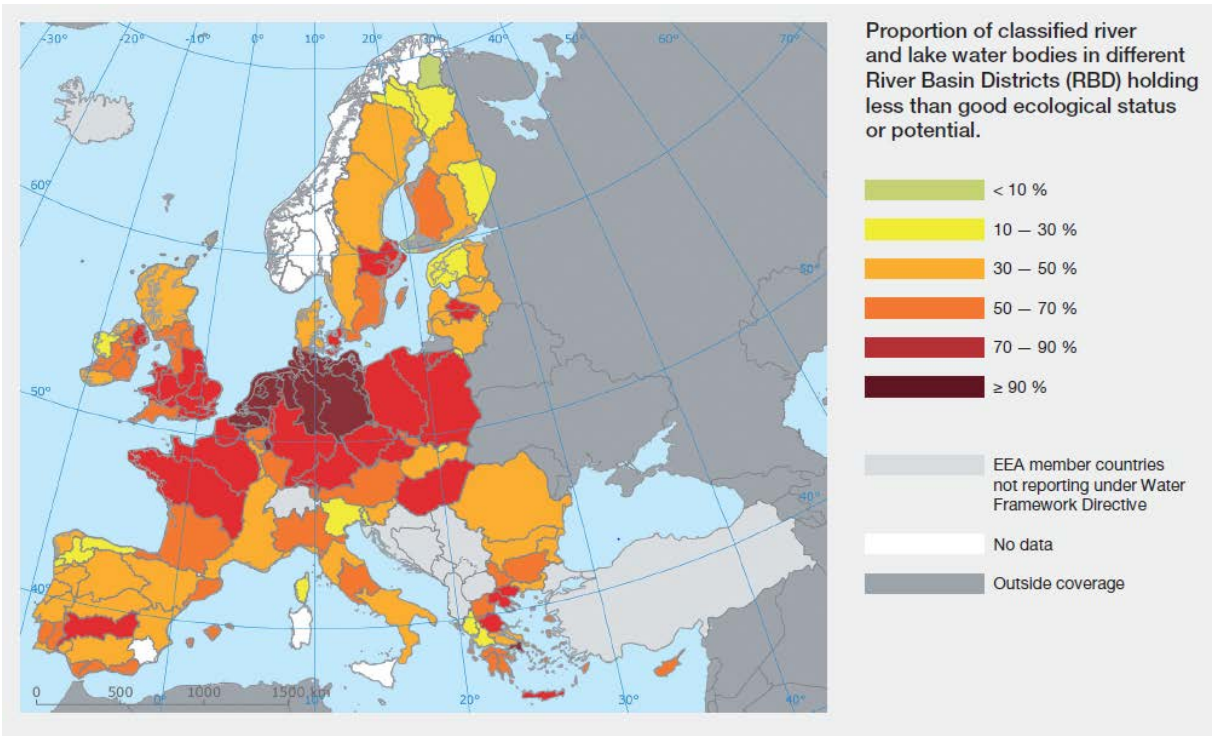


Figure 4.47: Proportion of rivers and lakes of less than “good” ecological status or potential in the European Union (European Environment Agency, 2012).

4.6.2.2 Trends in organic pollution

Emissions of easily degradable organic compounds is decreasing in Western and Central Europe thanks to improved sewage treatment and better storage of animal manure in agriculture, for example, as a result of effective regulations during the past 30 years (European Commission, 2012). However, several monitoring programmes have detected significant increases in the concentration of dissolved organic carbon since 1990 in Western Europe (Monteith et al., 2007). Water colour, an easily observable consequence of organic matter in the water, has changed markedly in lakes and rivers across the boreal zone in the past decades and this trend is likely to continue (De Wit et al., 2016). Currently, surface waters in northern waters are browning as a result of reduced acid deposition (Garmo et al., 2014; Monteith et al., 2007) and increased precipitation (De Wit et al., 2016).

Although the causal relationships are not straightforward, a combination of climate change induced increases in run-off and temperature, and indirect changes in terrestrial vegetation (Meyer-Jacob, Tolu, Bigler, Yang, & Bindler, 2015) are projected to increase organic matter loads in future (Hejzlar, Dubrovský, Buchtele, & Růžička, 2003). These increases will be strongest in the boreal zone of the region and in the Arctic, where thawing of permafrost is a further source of organic matter (Abbott, Larouche, Jones, Bowden, & Balser, 2014).

4.6.2.3 Drivers of organic pollution

Demographic and economic drivers have increased organic pollution from sewage, agriculture (livestock manure), aquaculture (fishponds and farms), and certain types of industries (such as dairy, or sugar refinery). Except for land-use change, the source of organic pollution is mainly point sources and therefore regulations and technological innovations have managed to reduce emissions (EEA,

20336 2012). Sewage overflows in connection with high precipitation events, however, remains a problem
 20337 (Rauch & Harremoës, 1996).

20338

20339 4.6.3 Acidification

20340 Acidifying substances such as sulphur dioxide (SO₂), ammonia (NH₃) and nitrogen oxides (NO_x) undergo
 20341 chemical transformation into acids as they are dispersed in the atmosphere. Their subsequent
 20342 downwind deposition leads to acidification of the soil and surface water.

20343

20344 4.6.3.1 *Effects of acidification on biodiversity and nature's contributions to people*

20345 Historically, SO₂ was the dominant pollutant causing acidification, but today NO_x are increasingly
 20346 important. Effects of terrestrial acidification from nitrogen were briefly assessed in Section 4.6.1.1.
 20347 Anthropogenic acidification has profound, well-documented ecological impacts, including the loss of
 20348 many acid-sensitive species from all trophic levels (e.g. Hildrew & Ormerod, 1995; Likens & Bormann,
 20349 1974; D. W. Schindler, 1988). In catchments with an insufficient supply of base cations to buffer acidity,
 20350 runoff to freshwater ecosystems becomes strongly acidic and at a pH of 5.5, alkalinity falls to zero and
 20351 inorganic aluminium concentration rises to become toxic to many forms of life, including almost all fish
 20352 (D. W. Sutcliffe & Hildrew, 1989).

20353 Despite reduced emissions there is still a legacy effect on biodiversity. Evidence for biological recovery
 20354 from anthropogenic acidification has therefore been much less obvious than changes in, for example,
 20355 water chemistry (Battarbee, Shilland, Kernan, Monteith, & Curtis, 2014). Soil and surface water
 20356 acidification remains an issue in the most sensitive areas of Nordic countries, the United Kingdom and
 20357 Central Europe (EEA, 2017). Kernan et al. (2010) found that invertebrate assemblages showed signs of
 20358 partial recovery at around half of sites in the UK acid water monitoring network that had recovered in
 20359 terms of water chemistry and even less showed any evidence of recovery of salmonid populations
 20360 (Malcolm et al., 2014; Murphy et al., 2014).

20361

20362 4.6.3.2 *Trends in acidification*

20363 In Western and Central Europe (EEA-33) emissions of SO₂ decreased by 74% between 1990 and 2011
 20364 (EEA, 2016a). **Figure 4.49** illustrates this trend, which is projected to continue (**Figure 4.50**). Within the
 20365 European Union, NO_x emissions decreased by 49% between 1980 and 2011 (EEA, 2014b), or by 40%
 20366 between 2000 and 2010 (EEA, 2016a). Data is limited from other regions and contingent on economic
 20367 activity; as an example, NO_x emissions in Montenegro dropped after 1990 but increased to the same
 20368 level in 2009 (EEA SOER, 2015).

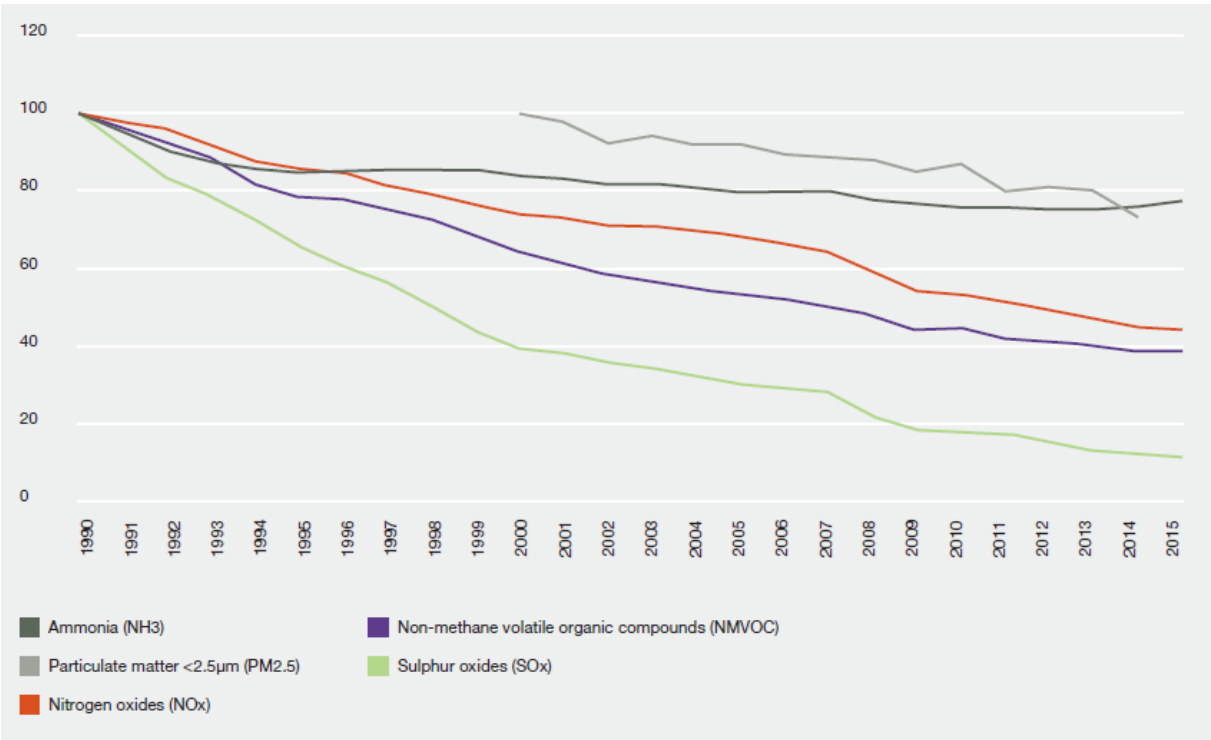


Figure 4.48: Emissions of air pollutants, EU-28, 1990-2015, Index 1990=100. Note: PM2.5 time series start in 2000. (Eurostat, 2016) http://ec.europa.eu/eurostat/statistics-explained/index.php/Air_pollution_statistics.

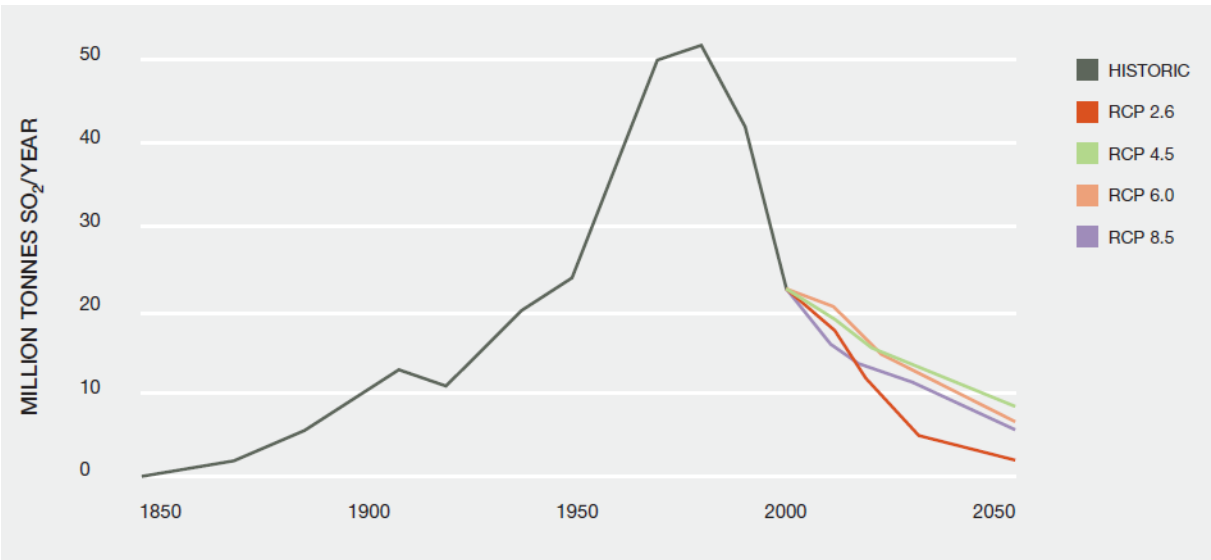


Figure 4.49: The emission of Western and Central Europe and this trend is projected to continue in all IPCC scenarios (EEA, 2014a). Representative concentration pathways (RCPs) are four greenhouse gas concentration (not emissions) trajectories adopted by the IPCC for its fifth assessment report (IPCC, 2013b).

20380 4.6.3.3 Drivers of acidification

20381 Anthropogenic NO_x and SO₂ are mainly caused by fossil fuel combustion. The basic drivers are economic,
20382 which Montenegro and Serbia may illustrate: During the period of sanctions on the former Yugoslavia
20383 (1990-1995), there was a significant drop in SO₂ and NO_x emissions, due to the overall reduction in
20384 economic activities. After 1995, emissions increased steadily with GDP (EEA & SOER, 2015; EEA SOER,
20385 2015). However, institutional drivers are key to push for technological change which, in the case of
20386 acidification, has been relatively simple. Regulations like the Sulphur Protocols (Section 4.6.1.1) have
20387 been effective in reducing acidification.

20388

20389 4.6.4 Xenochemical and heavy metal pollution

20390 Xenochemical pollution is the introduction or release of chemical substances into ecosystems where
20391 they are not naturally found.

20392

20393 4.6.4.1 Effects of xenochemicals and heavy metals on biodiversity and nature's contributions to 20394 people

20395 The polluting impact of many chemicals and heavy metals (e.g. polychlorinated biphenyl [PCB] and
20396 lead) are well-known, and their use and emission strictly regulated in most parts of Europe and Central
20397 Asia. There are, however, emerging threats to biodiversity and nature's contributions to people, which
20398 relate not only to recently introduced compounds but also to inappropriate use of listed toxic
20399 compounds, unknown effects of toxic mixtures, unknown effects of chemicals that have not undergone
20400 toxicological testing (e.g. hygiene products) and potentially aggravating effects of climate change
20401 (Malaj et al., 2014).

20402 Xenochemicals primarily influence ecosystems and biodiversity in close proximity to urban areas,
20403 industry and agriculture although a number of studies have shown long range pollution of
20404 xenochemicals in air, water and biota. Toxicity of most of the emerging pollutants is unknown, as is
20405 knowledge on their persistence in the environment and ability to bioaccumulate. A large amount of
20406 literature has documented toxic effects of xenochemicals on both terrestrial and aquatic biota
20407 (Beketov, Kefford, Schäfer, & Liess, 2013; J. L. Pereira et al., 2009; Sabater et al., 2007). Impacts of toxic
20408 compounds on freshwater macroinvertebrates have been shown for heavy metals and pesticides
20409 (Heckmann & Friberg, 2005; Liess & Von Der Ohe, 2005; Rasmussen, Friberg, & Larsen, 2008; Schäfer
20410 et al., 2007).

20411 Studies have shown increases of Priority Hazardous Substances like mercury in the aquatic food web,
20412 especially fish (Åkerblom et al., 2014), to levels that exceed advised limits for humans and can have
20413 negative impacts on wildlife (Scheulhammer et al., 2007). Various synthetic compounds acting as
20414 hormone disruptors (e.g. BPA and other bisphenols, phthalates, etc.) have direct negative effects on
20415 nature's contributions to people (EEA, 2012c).

20416 Multiple chemicals interact in the environment, producing combined ecotoxic effects that exceed the
20417 sum of individual impacts (Kortenkamp et al., 2009). As a result, a substance present in concentrations
20418 below the threshold level may still contribute to combined and possibly synergistic effects. In
20419 particular, robust evidence exists of combination effects for hormone disrupting chemicals (EEA,
20420 2012c).

20421

20422 4.6.4.2 Trends in xenochemical and heavy metal pollution

20423 In Western and Central Europe more than 100,000 commercially available chemical substances are
 20424 registered in the European Inventory of Existing Commercial Chemical Substances (EINECS). Global
 20425 sales from the chemical industry sector doubled between 2000 and 2009, with increases in all world
 20426 regions (OECD, 2012), which is a development that is predicted to continue. The total sales of
 20427 pesticides across the European Union increased from 2011 to 2014 by 4 % to just under 400,000 tonnes
 20428 of active substances, despite the adoption of The Directive on the Sustainable Use of Pesticides in
 20429 2009. However, the aim of this Directive was not only to reduce the use of pesticides but to "promote
 20430 the use of less harmful pesticides and provide incentives to industry to develop pesticides with less
 20431 hazardous properties" (EEA, 2016b).

20432

20433 4.6.4.3 Drivers of xenochemical and heavy metal pollution

20434 Xenochemical pollution is integrated in all sectors of industrialized countries, driven by market forces
 20435 in general and globalization in particular. Public awareness has modified institutional drivers, e.g. the
 20436 European Union "Reach" legislation. However, the globalized characteristics of xenochemicals
 20437 combined with uncertainty concerning the effects of new substances inhibit effective regulations
 20438 (OECD, 2011).

20439

20440 4.6.5 Other pollution

20441 4.6.5.1 Ground-level ozone

20442 Ground-level ozone may have significant effects on biodiversity (Wedlich et al., 2012). These effects
 20443 include changes in species composition of semi-natural vegetation communities (e.g. Ashmore, 2005),
 20444 reductions in forest net primary productivity (Matyssek et al., 2003), also in combination with nitrogen
 20445 (Bobbink et al., 2010). Ozone pollution has been linked to the prevalence of damage in mountain
 20446 forests: the acute effects of O₃ involve visible injuries to leaves and shoots and changes in physiological
 20447 processes and metabolism.

20448 The emission of O₃ or ozone precursor gases has recently decreased considerably in Western and
 20449 Central Europe (EEA, 2015c). However, the ground-level concentrations of O₃ have remained stable or
 20450 even increased due to long-range transport from outside Western and Central Europe (EEA, 2015c). As
 20451 a result, most types of vegetation and almost all crops (88% of Western and Central Europe's
 20452 agricultural area, mainly its southern and eastern parts) are exposed to levels above the critical load,
 20453 especially near roads with heavy traffic. Drivers of nitrogen concentration and ozone formation
 20454 interact, which calls for integrated policy responses (e.g. see Table 6.1 in Chapter 6).

20455

20456 4.6.5.2 Light pollution

20457 Light pollution is generated by the use of artificial light at night and affects terrestrial, aquatic and
 20458 marine ecosystems (Davies, Duffy, Bennie, & Gaston, 2014; Longcore & Rich, 2004). It is related to
 20459 material affluence and concerns 23% of global land surface and 88% in Western and Central Europe
 20460 (Davies et al., 2014). Temperate and Mediterranean ecosystems have experienced the greatest
 20461 increase in exposure to artificial lighting (Jonathan Bennie, Duffy, Davies, Correa-Cano, & Gaston, 2015)
 20462 and a significant increase in average nighttime lighting has been reported in 32 % of Western and
 20463 Central European terrestrial protected areas since 1995 (Gaston, Duffy, & Bennie, 2015). This rate is
 20464 expected to increase in the coming decades because of the replacement of existing lighting

20465 infrastructure by broad-spectrum white lighting technologies (such as LEDs), which is expected to
20466 double the perceived night sky brightness.

20467 Light pollution also dramatically influences movements and distributions of nocturnal species, which
20468 represent 30% of mammals and 60 % of invertebrates worldwide (Hölker, Wolter, Perkin, & Tockner,
20469 2010). Nocturnal insects present a “flight-to-light behaviour” (Altermatt, Baumeyer, & Ebert, 2009),
20470 which generates insect biomass accumulation in illuminated patches and depletion in surrounding dark
20471 areas. Unnatural polarized light sources, e.g. from building materials, can also trigger maladaptive
20472 behaviors in polarization-sensitive taxa and alter ecological interactions (Horváth, Kriska, Malik, &
20473 Robertson, 2009).

20474 Light pollution induces major shifts in biological communities by disrupting the interspecific balance of
20475 trophic and competition interactions (J. Bennie, Davies, Cruse, Inger, & Gaston, 2015; Davies, Bennie,
20476 Inger, de Ibarra, & Gaston, 2013; Knop et al., 2017; Rydell, Entwistle, & Racey, 1996). This can have
20477 profound impacts on ecosystem functions such as pest control, pollination, and seed dispersal. For
20478 example, moths carry less pollen in light-polluted areas than in dark areas (Macgregor, Evans, Fox, &
20479 Pocock, 2017), which in turn may impact the fitness of insect-pollinated plant species (Macgregor,
20480 Pocock, Fox, & Evans, 2015). Additionally, light pollution induced large-scale phenology changes in UK
20481 deciduous tree budburst (Ffrench-Constant et al., 2016). The large spatial scale impacts of light
20482 pollution likely interact and accentuates the adverse impacts of both land use and climate changes on
20483 biodiversity.

20484

20485 4.6.5.3 *Marine and beach plastic debris*

20486 Polymers are part of our everyday life. Annual production rates continue to grow and have risen from
20487 1.7 million tonnes in 1960 to 322 million tonnes in 2015, with a current mean annual increase of 4%
20488 (Plastics Europe, 2016). Plastic debris and microplastics can affect a wide array of marine organisms,
20489 from plankton (Collignon et al., 2012) to filter feeding marine organisms (Fossi et al., 2014; von Moos,
20490 Burkhardt-Holm, & Köhler, 2012) and large pelagic fish (Romeo et al., 2015). Size, shape and
20491 abundance of plastic debris influence uptake; microfibrs are considered most harmful (Wright,
20492 Thompson, & Galloway, 2013). Plastics inhibit digestion and can transfer attached chemical pollutants
20493 into the animal tissues (Browne, Niven, Galloway, Rowland, & Thompson, 2013). As a result of
20494 increasing awareness, developing new polymeric materials today often includes assessment of its
20495 durability and its degradation time when exhausted (Hottle, Bilec, & Landis, 2013).

20496

20497 4.6.6 *Synthesizing drivers of pollution*

20498 The passage of matter through our economy and society, from resource extraction to waste, is the
20499 premise for pollution. All factors affecting the size and the quality of the material throughput of our
20500 societies (Boulding, 1966) are drivers of pollution. In the 1990s, particularly in Europe, the need for a
20501 shift from end-of-the-pipe policies to prevention became evident. Several studies highlighted this
20502 (Adriaanse et al., 1997; E. Matthews et al., 2000; Weizsäcker, Lovins, & Lovins, 1997) so that material
20503 flow data eventually entered the official statistics of the European Union.

20504 For the above reasons, pollution is driven by the same drivers that are highlighted for natural resource
20505 extraction, land-use change, and invasion of alien species, and climate change (which can be seen as a
20506 form of pollution). This is also evident from **Table 4.6** (introduction to Section 4.6) that summarizes
20507 the main pollution problems and their drivers. As synthesized by **Figure 4.51** below these drivers are
20508 mainly economic, i.e. effects of industrialization and globalization and its subsequent increase in

transportation. Pollution also increases by population growth, institutional drivers that foster adverse technological development, and the cultural belief that a prosperous life must entail more material consumption (T. Jackson, 2009). Technological innovation usually increases production and transportation but may also change the material intensity of GDP and production technology to reduce waste and pollution. Recent institutional drivers have succeeded in developing technologies for reducing some pollutants in Europe, especially point sources like air pollutants from industrial effluents (including SO₂, NO_x, lead) and municipal waste water. However, the drivers of xenochemicals and nutrient leakage (NH₃) from agriculture have not successively been reversed.

Figure 4.51 depicts the main causal loops for pollution, emphasising industrial and agricultural production and transportation. There are two feedback loops in **Figure 4.51**. First, the public awareness of pollution influences regulations via political pressure. Second, awareness influences cultural beliefs and consumption patterns, which may alter the material intensity of GDP.

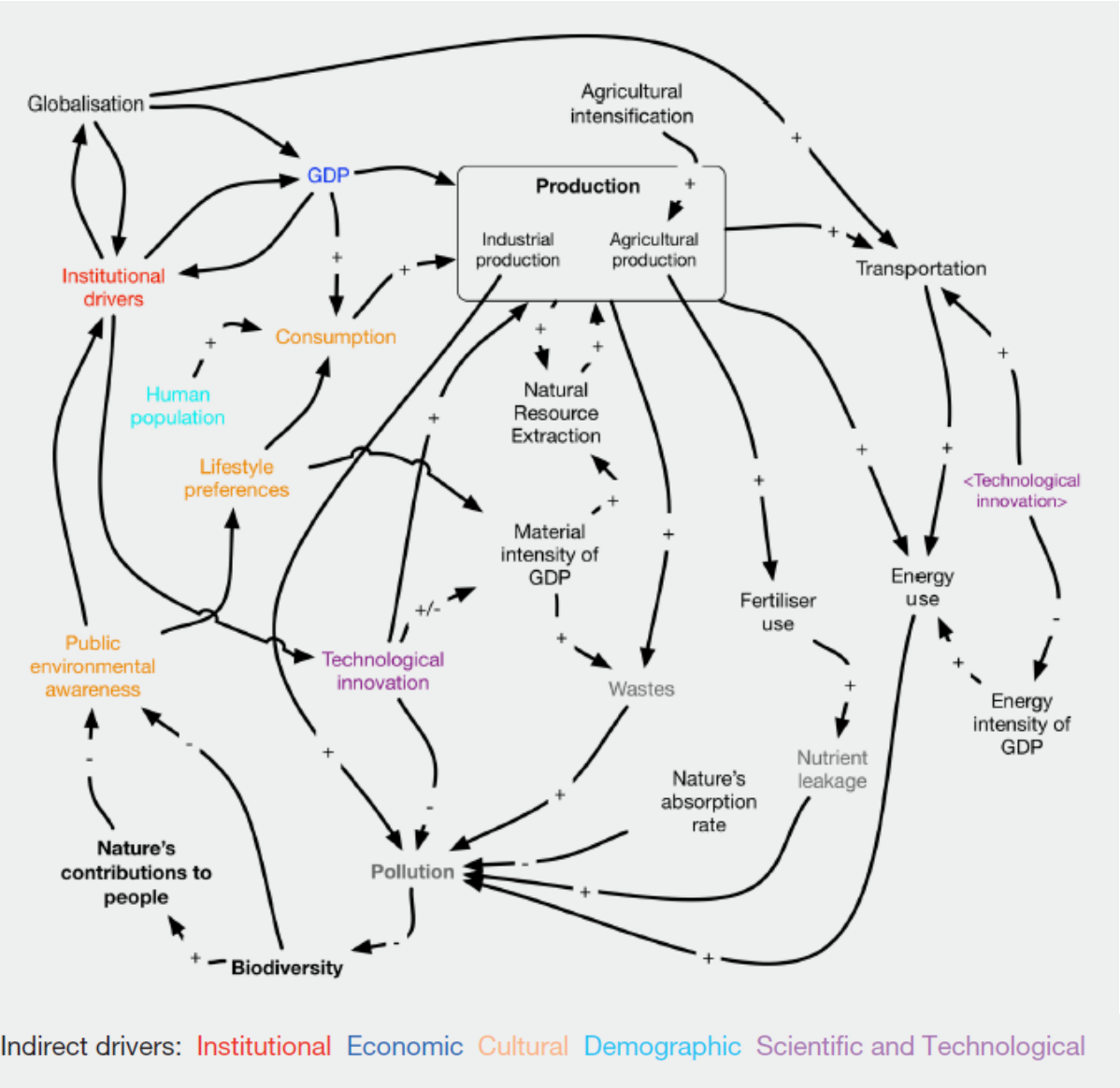


Figure 4.50: Causal loop diagram of drivers of pollution.

4.7 Drivers and effects of climate change

4.7.1 Effects of climate change on biodiversity

Climate change is a complex driver of ecosystem change, consisting of changes in precipitation and temperature patterns which lead to changes in drought, flood, and fire risk, ocean-atmosphere interchange, marine circulation and stratification, and the concentrations and distribution of O₂ and CO₂ in the atmosphere and in the ocean (IPCC, 2014a). These impacts affect species and influence and modulate important ecosystem functions and processes that underpin human livelihoods and nature's contributions to people, such as water regulation, food production, and carbon sequestration (CBD, 2016; Gallardo, Zieritz, & Aldridge, 2015; IPBES, 2016a; IPCC, 2014a; MA, 2005a).

There is strong evidence that climate change affects the biodiversity of Europe and Central Asia through shifts in the timing of species' life-history events, growth, reproduction and population dynamics, and in their ranges and habitat occupancy. The evidence for impacts on the ecological processes underlying range shifts, such as species interactions, is rapidly accumulating. Knowledge gaps remain with respect to changes in physiological processes and evolutionary adaptations to new climatic conditions (Céline Bellard, Bertelsmeier, Leadley, Thuiller, & Courchamp, 2012; Merilä & Hendry, 2014).

Climate change impacts are not as strong as we would expect given recent changes in climate. In particular, many species-level responses lag behind the rate of change in climate drivers. These lags are caused in part by dispersal and establishment constraints and by biotic interactions that stabilize extant populations and communities, and in part by the fact that the rates and nature of climate are regionally variable and may only slowly be exceeding the historical range of variability (see **Figure 4.52**; see also Section 4.7.1.2). In Europe and Central Asia, northern areas are projected to experience fast spatial displacement of climate. Therefore, dispersal-related responses may be particularly important, mountainous regions will be subject to local divergences between temperature and precipitation drivers, and novel climates are more likely to appear in the Mediterranean area (Ordonez, Williams, & Svenning, 2016). Climates outside the current range of variability are a particular threat as populations are unlikely to contain adapted individuals or genes. For a given rate of underlying climate change, novel conditions may be experienced sooner in highly variable systems, though such systems will also occasionally experience historically "normal" years further in the future (**Figure 4.52**).

Complex responses and interplay between direct and indirect effects of multiple climate change drivers challenge our ability to project future trends in nature's contribution to people. Additional interactions with other anthropogenic drivers, such as reinforcement of ocean acidification and land-use change (Cloern & Jassby, 2012; Mantyka-Pringle, Martin, & Rhodes, 2012; Riebesell & Gattuso, 2014) further exacerbate the complexity. As gradual changes in mean climatic conditions can have dramatically different consequences for biodiversity, including ecosystems, compared with changes in the variability of short-term weather, the two are treated separately. Then, important secondary effects of climate change on ecosystems are briefly assessed.

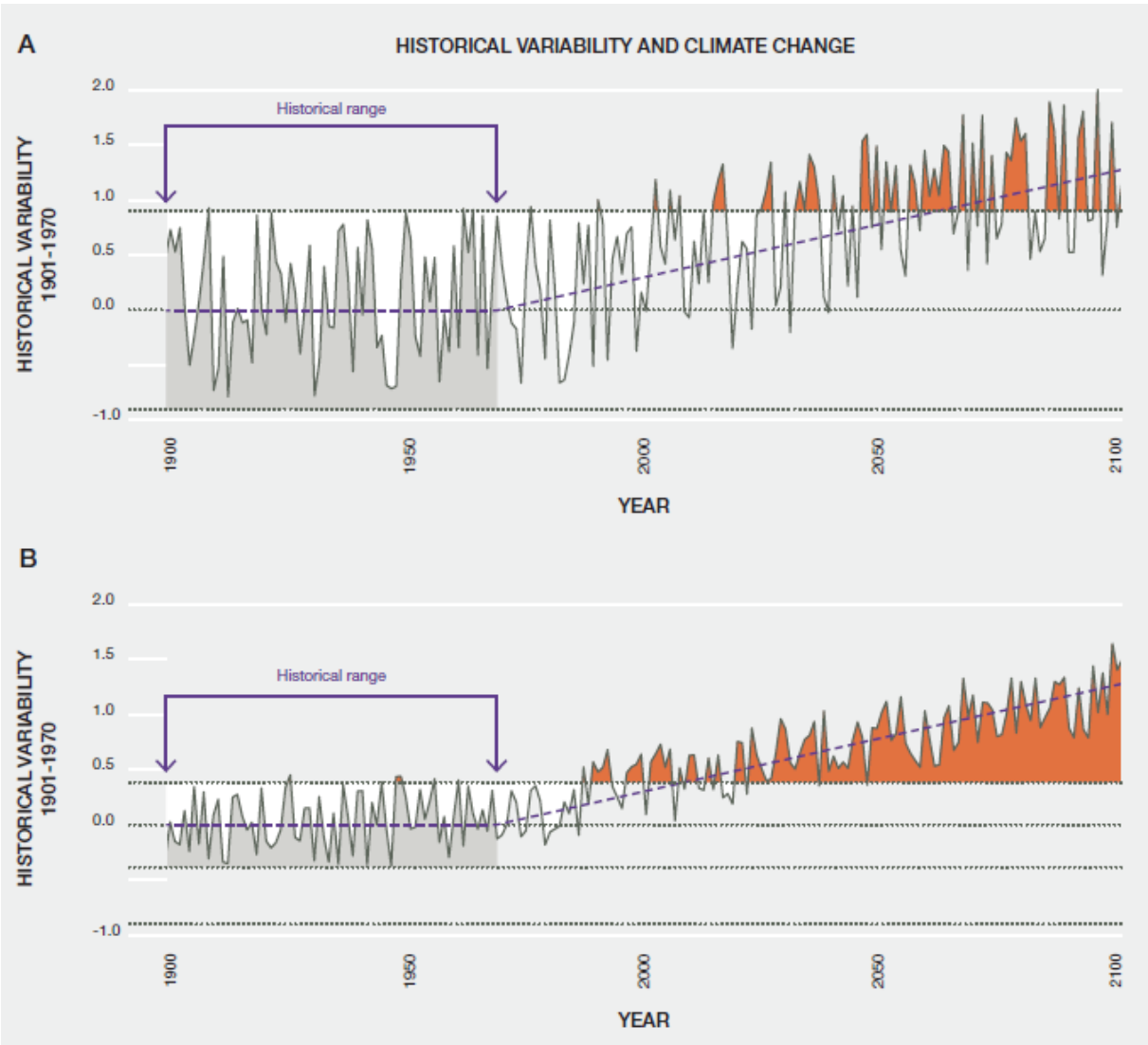


Figure 4.51: Illustration of the link between climate variability and mean trend. The simulated historical range of climate variability is high in panel A and low in panel B. No trend in climate mean is simulated between 1900-1970 and shows the increasing mean trend from 1970-2100 in A and B. The red zone denotes years in which the historical range of variability is exceeded, which is observed much more rapidly in panel B (compared to A). Illustration follows Beaumont et al. (2011).

4.7.1.1 Effects of gradual climate change

4.7.1.1.1 Effects on phenology, growth and fitness

It is well documented that recent climate change has affected phenology, but there is considerable variation across regions, biomes, and taxa (Cleland et al., 2012; Cook, Wolkovich, & Parmesan, 2012; Ma & Zhou, 2012; Parmesan, 2006, 2007; Wolkovich et al., 2012). In Western Europe, standardized assessments have confirmed phenological advancement in terrestrial, freshwater and marine plants and animals (Menzel et al., 2006; Thackeray et al., 2010). Phenological changes are often linked to changes in the onset and duration of the growing season, potentially affecting species and ecosystems. These effects can be both direct, on the survival and population dynamics of individual species (e.g., “developmental traps”: prolonged seasons that allow multiple generations of insects but leave the autumnal cohort vulnerable (Van Dyck, Bonte, Puls, Gotthard, & Maes, 2015)), and indirect from e.g.,

phenological mismatches between plants and pollinators (Joar Hegland & Totland, 2008); between predators and prey (Petitgas, Secor, McQuinn, Huse, & Lo, 2010; Raab et al., 2013; M. E. Visser, Holleman, & Gienapp, 2006); and between multiple trophic levels (Edwards & Richardson, 2004; Luczak et al., 2012; Möllmann & Diekmann, 2012)).

In animals, there are indications of climate change impacts on growth and body size, for example in otters (Yoram Yom-Tov et al., 2010; Yoram Yom-Tov, Heggberget, Wiig, & Yom-Tov, 2006) and birds (S. Yom-Tov, Yom-Tov, Wright, Feu, & Lindström, 2006; Y Yom-Tov, 2001). The strength and direction of the linkage to climate change is not very clear, as effects are mostly indirect through changes in net primary production and thus food availability (Yoram Yom-Tov & Geffen, 2011). Body size decreases consistently across freshwater taxa under warming (Daufresne, Lengfellner, & Sommer, 2009). In marine systems, high temperatures are particularly stressful for vulnerable life stages of coastal zooplankton, especially larvae (Przeslawski, Byrne, & Mellin, 2015). For plants, warming will increase growth and size until reaching a point where other factors limit growth. For example, the largest warming experiment in the region found that climate warming increased alpine plant growth, but only in the first few years, possibly due to onset of nutrient or water limitation later on (Arft et al., 1999).

Climatic factors can also act as forces of selection, driving adaptive differentiation between and within populations at fine spatial scales despite potentially high levels of gene flow (Anderson, Panetta, & Mitchell-Olds, 2012). Plant populations may adapt in situ via selection on standing genetic variation in response to climate change (Alistair S. Jump, Marchant, & Peñuelas, 2009). Genetic differentiation in response to temperature or moisture gradients has been observed in plants at both fine spatial scales (e.g. C. K. Kelly, Chase, de Bruijn, Fay, & Woodward, 2003) and across landscapes (e.g. Alistair S. Jump, Hunt, Martínez-Izquierdo, & Peñuelas, 2006). Such patterns of genetic structuring are highly indicative of adaptive differentiation in response to environmental selection, which has been confirmed by direct experimental tests of genetic responses to climate change in plant species within intact ecosystems (e.g. A. S. Jump et al., 2008; Ravenscroft, Whitlock, & Fridley, 2015). However, despite this potential for genetic responses, a number of recent reviews of both terrestrial and marine systems find little direct evidence for adaptive genetic responses to current climate change (Boutin & Lane, 2014; Donnelly et al., 2012; Reusch, 2014; Teplitsky & Millien, 2014). In cases where genetic changes are documented, it is still unclear whether these reflect adaptive responses, whether they are directly caused by climate change, and whether they are sufficient to keep up with future climatic changes (Franks, Weber, & Aitken, 2014). Even in species with the highest adaptive potential, widespread species with large populations and high fecundity, adaptational lags are likely under future climatic changes (Aitken, Yeaman, Holliday, Wang, & Curtis-McLane, 2008).

4.7.1.1.2 Effects on biodiversity and community dynamics

Shifts in species ranges in response to climate change are relatively well documented for Europe and Central Asia. Latitudinal and altitudinal shifts in species distributions have been found for many taxa, e.g. 80% of studied taxa in a global meta-analysis by Root *et al.* (2003); for marine systems see Perry et al. (2005), Beaugrand et al. (2014). Northwards migrations of warm-adapted species and associated loss of cold-adapted species have been documented for the Barents Sea and North East Atlantic (G. Beaugrand, Luczak, & Edwards, 2009; G. Beaugrand & Reid PC, Ibañez F, Lindley JA, 2002; Brander, Blom, Borges, Erzini, & Henderson, 2003; Fossheim et al., 2015), resulting in increased species richness of zooplankton (G. Beaugrand, Edwards, & Legendre, 2010) and fish (Hiddink & ter Hofstede, 2008). Northward range shifts (12.5-19 km per decade) are also prevalent among terrestrial species, including arthropods, birds and mammals (Hickling, Roy, Hill, Fox, & Thomas, 2006). Similar range shifts are found along altitudinal gradients, but are not ubiquitous across a broad range of taxonomic groups

(Benito, Lorite, & Peñas, 2011; Grytnes et al., 2014; Nogués-Bravo, Araújo, Romdal, & Rahbek, 2008), while downslope or no shifts also occur (Lenoir et al., 2010). While evidence for range shifts is mounting, the unequivocal attribution to climatic warming is not always clear, as the magnitude of shifts cannot always be predicted from observed climatic changes (Grytnes et al., 2014).

Climate change does not affect species ranges and biodiversity equally in all regions or for all taxa (e.g. Garrabou et al., 2009; Paireud, Bensoussan, Garreau, Faure, & Garrabou, 2014; Tunin-Ley, Ibañez, Labat, Zingone, & Lemée, 2009). Negative impacts are likely strongest where species' latitudinal and altitudinal shifts are physically limited, for example in the case of mountaintops, northernmost or southernmost areas. The ranges of birds inhabiting northern Fennoscandia are strongly controlled by temperature, and will likely no longer overlap with terrestrial land areas in the future (Virkkala, Heikkinen, Leikola, & Luoto, 2008). Strongly negative impacts can also be expected in taxonomic groups with high species turnover along climate gradients and with small range sizes, as for birds in Central Asia (La Sorte, Butchart, Jetz, & Böhning-Gaese, 2014), and in biodiversity hotspots, as for the highly diverse reptile fauna of the Central Asian Mountains (Ficetola, Bonardi, Sindaco, & Padoa-Schioppa, 2013). Despite individual responses, an overall homogenization of biodiversity has been projected from model experiments for birds in Western and Central Europe (Thuiller et al., 2014), indicating that taxonomic, phylogenetic and functional turnover decrease between regions. Relatively low and slow responses in range dynamics may not imply that climate change does not matter. Rather, it may reflect lagged responses, also known as climatic extinction debts (Devictor et al., 2012; Dullinger et al., 2012), and homogenization of regional species pools (Thuiller et al., 2014).

Species shift their ranges at individual rates and directions (see above), which will result in novel assemblages (J. M. Alexander, Diez, & Levine, 2015), and may change the intensity of species interactions, such as increased interspecific competition (Olsen, Töpper, Skarpaas, Vandvik, & Klanderud, 2016), dampened herbivore cycles (Cornulier et al., 2013), and changes in predator-prey dynamics (Schmidt et al., 2012; Terraube, Arroyo, Madders, & Mougeot, 2011; Winder & Schindler, 2004). Such indirect impacts may be particularly important at the warmer-climate distributional edge of species ranges, where the intensity of interactions may be higher, and could lead to loss of specialized interactions (pollination, predator-prey, dispersal, consumer, trophic, etc.) to be replaced by generalists (Lurgi, Lopez, & Montoya, 2012).

Some of this context-dependency in species' ability to withstand climatic change can be predicted by species traits. For example, a global analysis indicates that thick leaves, high below-ground biomass, and tall growth are key traits for montane grassland species' ability to withstand climatic warming (Willis et al., 2017). This is empirically confirmed for the Norwegian mountain flora (Guittar, Goldberg, Klanderud, Telford, & Vandvik, 2016) and plants in the Caucasus Mountains (Soudzilovskaia et al., 2013), where the losers under climate change are plants lacking these traits.

A warmer climate will not only have negative impacts on species richness. As can be observed for many taxa, the biodiversity of algae in the south-Tajik depression (Barinova et al., 2015), and zoobenthos in the Onega Bay of the White Sea (Denisenko, 2010) both increase towards warmer regions. Functional shifts have also been observed. In Georgia, a shift towards a higher species richness of ants is expected, at the expense of a decreased species richness of spiders (Chaladze, 2012; Chaladze, Otto, & Tramp, 2014). However, the predictive ability of climate change responses based on such spatial gradients will be modified by nonlinearities (Nagorskaya & Keyser, 2005).

20670 4.7.1.1.3 Effects on ecological processes and ecosystem functioning

20671 It is well documented that climate change impacts vegetation and ecosystem functioning in Europe
 20672 and Central Asia, but strength and direction depend on region, unit of analysis, and on the nature of
 20673 the climatic changes. The relative importance of climate change and other concurrent drivers on
 20674 ecosystem functioning are hard to disentangle.

20675 Under increased temperatures, soil respiration, microbial activity (Sowerby et al., 2005) and
 20676 decomposition of lignified materials (Zell, Kändler, & Hanewinkel, 2009) increase, but only if there is
 20677 adequate moisture (Poll, Marhan, Back, Niklaus, & Kandeler, 2013). In the Mediterranean,
 20678 temperatures are already close to the optimum for photosynthesis, so warming mainly increases plant
 20679 water loss, whereas in temperate areas a warming of 1°C can increase biomass production by as much
 20680 as 15% (Peñuelas et al., 2004). In the UK, experimentally-increased temperatures led to a decrease in
 20681 soil nitrogen leaching, probably due to increased nitrogen uptake because of increased plant growth
 20682 (Ineson, Benham, et al., 1998; Ineson, Taylor, et al., 1998). Warming also has a negative effect on soil
 20683 biota abundance at all trophic levels, especially in cold dry regions, affecting their ecosystem functions
 20684 (J. J. C. Blankinship, Niklaus, & Hungate, 2011; Briones, Ineson, & Heinemeyer, 2007).

20685 Changing precipitation jointly impacts plants and biogeochemical cycles, a phenomenon well studied
 20686 in Western and Central Europe with >70 experimental sites manipulating precipitation. Global meta-
 20687 analyses reveal that plant biomass, productivity, respiration, ecosystem photosynthesis, and net
 20688 carbon uptake are generally stimulated by increased precipitation and suppressed by decreased
 20689 precipitation (Vicca & Bahn, 2014; Wu, Dijkstra, Koch, Peñuelas, & Hungate, 2011). Ecosystems are
 20690 generally more sensitive to increased, than to reduced precipitation. Precipitation also affects
 20691 decomposition, with coarse woody debris decay rate peaking at around 1,250 mm annual precipitation
 20692 in temperate Western Europe (Zell et al., 2009). Microbial soil communities in the northern parts of
 20693 Western Europe may be more sensitive to changes in rainfall patterns than more moisture-limited soils
 20694 in the southern parts of Western European (Sowerby et al., 2005). Winter precipitation change also
 20695 affect ecosystems, and snow depth manipulation experiments find that decreasing snow depth may
 20696 reduce soil CO₂ efflux, increase N₂O efflux, and increase mobile nitrogen concentration (J. C.
 20697 Blankinship & Hart, 2012).

20698 Gradual warming favours harmful cyanobacterial blooms in freshwater systems, particularly in
 20699 combination with eutrophication (O'Neil, Davis, Burford, & Gobler, 2012). Warming will increase the
 20700 spread of invasive fish in freshwater ecosystems, as cold seasons currently limit the spread of many
 20701 freshwater invasive species (Rahel & Olden, 2008). Anadromous fish important for recreational fishing
 20702 (salmonids) will shift their ranges northwards and suffer negative effects of warming in dry areas due
 20703 to reduced river flows (B. Jonsson & Jonsson, 2009). Reduced precipitation will directly reduce water
 20704 supply but considerable uncertainties remain regarding the impact of changing temperature and
 20705 precipitation regimes on water quality. A review focussed on the UK found that there is insufficient
 20706 evidence to link observed decreases in water quality to climate change (Watts et al., 2015).

20707 In oceans, recent temperature-driven changes in species ranges have strongly affected the
 20708 trophodynamics of North East Atlantic ecosystems (Goberville, Beaugrand, & Edwards, 2014; Luczak,
 20709 Beaugrand, Jaffre, & Lenoir, 2011) as well as benthic-pelagic coupling (Albouy et al., 2013; R. Kirby et
 20710 al., 2007). Increased vertical stability (strengthening of water stratification) leads to decreasing
 20711 nutrient replenishment, which leads to changes in phytoplankton bloom phenology (Herrmann,
 20712 Estournel, Adloff, & Diaz, 2014), biomass and community structure (Bosc, Bricaud, & Antoine, 2004;
 20713 Goffart, Hecq, & Legendre, 2002; Tunin-Ley et al., 2009). Reduced nutrient availability and
 20714 phytoplankton biomass strengthens the microbial pathway in the plankton ecosystem (Bosc et al.,
 20715 2004; Goffart et al., 2002; Tunin-Ley et al., 2009). A reduction in primary production and reduced

upwelling intensity will also have negative impacts on fisheries (Chassot et al., 2010). In Mediterranean systems, warming leads to a shift in plankton communities towards smaller species, and a decrease in diatoms (Durrieu de Madron et al., 2011). Temperature increase will, however, increase the metabolic activity of the surviving species, and modelling suggests that this could compensate for the species loss, resulting in similar net primary production by 2100 (Lazzari et al., 2014).

4.7.1.2 Effects of extreme events on biodiversity

Climate change leads to more extreme and less predictable weather events (heat waves, droughts, floods, heavy precipitation, windstorms) that impact biodiversity across ecosystems. Ecosystem response to climate extremes depend upon the ecosystem itself, in particular on whether productivity is precipitation-, radiation- or temperature-limited (Seddon, Macias-Fauria, Long, Benz, & Willis, 2016). The spatial distribution of Central European forest trees is partly explained by climatic extremes, in addition to average climate, suggesting such extreme events have long-term distribution-wide impacts (Zimmermann et al., 2009).

Observations of extreme weather events are important sources of information on ecosystem responses. For example, the unusually hot and dry summer of 2003 in Western and Central Europe resulted in decreased primary productivity and increased net carbon flux to the atmosphere (Ciais et al., 2005; Reichstein et al., 2007). Trees growing at high elevations in the Alps benefitted due to release from snow cover while there was decreased growth of lower-elevation trees due to increased evapotranspiration (Jolly, Dobbertin, Zimmermann, & Reichstein, 2005). The decrease was greatest in grasslands and croplands (Reichstein et al., 2007), while among forests beech and Mediterranean broadleaved forests were the most susceptible (Granier et al., 2007). Species richness also decreased in several heathlands across Western and Central Europe except for cool, damp heathlands in the UK (Peñuelas et al., 2007). Similarly, other droughts have been shown to reduce carbon flux from roots to the soil compartment in north-western Europe (Gorissen et al., 2004), to reduce the number of flowering shoots (Peñuelas et al., 2004), and to cause forest dieback in the Arkangelsk region (Aakala & Kuuluvainen, 2011) and southern Siberia (Kharuk, Im, Oskorbin, Petrov, & Ranson, 2013), altering forest vulnerability to damaging agents and pathogens (Jactel et al., 2012; Morley & Lewis, 2014). Across Central Asia, drought had affected grasslands, shrublands and areas of sparse vegetation, and the desertification risk in the Kakheti Region, the most drought-sensitive part of Georgia, is driven by increased drought frequency (Basialashvili, Matchavariani, & Lagidze, 2015). Experimental evidence is now emerging to complement the observational evidence on extreme events. However, published studies largely focus on Western and Central European grasslands, for which there is a broad range of experimental evidence that growth and biomass accumulation recover rapidly from drought (Geels et al., 2015).

The impact of an extreme event on biodiversity and nature's contributions to people is highly contingent on the timing of the event. In Arctic and alpine regions, short-term heat waves in winter have the greatest negative impact on productivity in the following summer (S. Bokhorst, Bjerke, Street, Callaghan, & Phoenix, 2011; S. F. Bokhorst, Bjerke, Tømmervik, Callaghan, & Phoenix, 2009). Ice forming on vegetation, when winter precipitation falls as rain instead of snow, decreases the availability of vegetation to herbivores and in turn has negative consequences for top predators (B. B. Hansen et al., 2013; Brage B Hansen et al., 2014).

Freshwater systems are highly sensitive to temperature extremes, leading to habitat and species loss under drought events (W. J. Matthews & Marsh-Matthews, 2003; Woodward et al., 2016). Heatwaves lead to the proliferation of toxic algal blooms, reducing both biodiversity and the provisioning of

drinking water (Gallina, Anneville, & Beniston, 2011; Jöhnk et al., 2008; Paerl & Paul, 2012). Floods, on the other hand, directly impact fresh water provisioning by increasing water turbidity and eutrophication (Khan et al., 2015). The protection from flooding and erosion provided by coastal and intertidal vegetation is reduced by increased storm activity (Cardoso, Raffaelli, Lillebø, Verdelhos, & Pardal, 2008; Gedan, Kirwan, Wolanski, Barbier, & Silliman, 2011; Kinsella & Crowe, 2015). Drought has affected nutrient leaching into lakes, with knock-on effects on aquatic communities, with rotifers and cladocerans dominating during dry periods and copepods dominating during wet periods (Krylov, Kulakov, Chalova, & Tselmovich, 2013). In coastal systems, benthic macroinvertebrates suffered high mortality in the middle of the 2003 heat wave, exacerbated by nutrient stress (Garrabou et al., 2009).

Variability has always been part of natural systems. Climate extremes denote events that depart clearly from the past range of variability of a given unit of analysis or region. Systems with low natural variability are usually at risk of rapidly exceeding their natural range, while systems of high variability may depart from this range frequently, but return to historical conditions for longer into the future than systems with low variability (**Figure 4.52**). High latitude units of analysis are much less prone to completely depart from the historical range of variability than more equatorial units, due to the higher variability in the former and lower variability in the latter systems (Beaumont et al., 2011). On the other hand, the absolute departure from the historical range of variability is higher in systems with high variability, and strong extremes (strong departures) may build more rapidly in such highly variable systems, with devastating effects from single events.

4.7.1.3 Secondary climate effects

While air temperature and precipitation changes may be seen as primary climate changes, other warming effects are also important for biodiversity and ecosystem function. Here we consider permafrost melting, atmospheric CO₂, ocean acidification and stratification, and sea level rise. Decreased precipitation and increased temperature also lead to an increased risk of fire (see Section 4.7.2).

As permafrost is the second largest terrestrial carbon pool (after soil), there is the potential for release of large amounts of carbon and methane when it thaws, thereby intensifying global warming and its earlier-mentioned effects on biodiversity; including ecosystems (Zhang et al., 2017). Thawing permafrost has been shown to result in shrinking lakes due to drainage (Smith, Sheng, MacDonald, & Hinzman, 2005), rapidly eroding river banks, the disappearance of wildlife including fish and migratory birds, altered migration routes, and shifted distributions of birds, reindeer, and caribou, and has been suggested to increase the danger of forest fires. Further, it may change plant species composition and productivity, as a result of warmer temperatures and associated changes in soil hydrology (Schuur, Crummer, Vogel, & Mack, 2007; Turetsky, Wieder, Vitt, Evans, & Scott, 2007).

An increase in atmospheric CO₂ concentration, a major cause of climate change, directly impacts plant functioning. The increase in total plant biomass under elevated CO₂ is contingent on adequate other resources such as water and nutrients (Zheng & Peng, 2001). A recent global analysis combining remotely sensed leaf area index time-series with biogeochemical modelling revealed a significant increase in leaf biomass of land vegetation (termed “greening”) in many regions of the world, and thus a significantly altered biogeochemistry (Z. Zhu et al., 2016). This was primarily driven by CO₂ fertilization effects, which accounted for 70% of the greening – the remainder by climate change, nitrogen deposition and land-cover change. The greening also varied regionally. It was statistically significant in many parts of Western and Central Europe, and prominent in Eastern Europe, but not observed in Central Asia. Elevated CO₂ can increase root activity, the abundance of microflora and

microfauna, and particularly detritivores (J. J. C. Blankinship et al., 2011). These effects result in changes in ecosystem biogeochemistry and altered vegetation-atmosphere feedbacks.

Ocean acidification results from increased atmospheric CO₂ and affects organism physiology (e.g. calcification, dissolution), biology (e.g. reproduction, skeletogenesis) with potential consequences for ecosystem structure and functioning (e.g. resistance to disease, unbalance of predator-prey interaction) and global carbon cycle (Hofmann et al., 2010; Kroeker, Kordas, Crim, & Singh, 2010). In the Atlantic and Arctic oceans, all calcifying plankton organisms exhibited simultaneously abrupt shifts in abundance during the mid- to the late-1990s (Grégory Beaugrand, Edwards, Raybaud, Goberville, & Kirby, 2015). However, these large-scale ecological shifts appeared more correlated to changes in northern hemisphere temperature than to ocean acidification.

Changes in the UV-B radiation in oceans, caused by changes in the mixed-layer depth, impair photosynthesis, growth and reproduction (Llabrés et al., 2013; Neale, Helbling, & Zagarese, 2003). Increased stratification is expected in the Mediterranean Sea during the 21st century (Somot, Sevault, & Déqué, 2006), and this may modify the exposure of organisms and organic compounds to solar radiation and favour photochemical oxidation reactions. The extratropical North Atlantic Ocean and its adjacent seas may be an important carbon sink (Sarmiento et al., 2004). The carbon sink may become less efficient in a warmer world because of changes in phytoplanktonic types (floristic turnover) but also because upward mixing of nutrients will diminish due to increased stratification of the oceans (Bopp, Aumont, Cadule, Alvain, & Gehlen, 2005; Thomas, Bozec, Elkalay, & de Baar, 2004). Deepening of the nutrient gradient would favour coccolithophorids against the diatoms, which are the major sink agents of carbon (Cernieño et al., 2008). Indeed, coccolithophorids have increased in the North Sea during recent decades (Gregory Beaugrand, McQuatters-Gollop, Edwards, & Goberville, 2013).

A sea-level rise of 1 m, a realistic maximum projected by 2100, will affect primarily the heavily populated regions in Western Europe (mostly The Netherlands, but also Germany, Denmark and UK). Such drastic shifts will have a strong effect on coastal ecosystems, on sessile and migrating animals (birds; Iwamura et al., 2013), and on the structuring of the coastal biomes. A population of 21.7 million is calculated to be at risk in the inundation area (Rowley, Kostelnick, Braaten, Li, & Meisel, 2007).

4.7.2 Trends in climate change

4.7.2.1 Temperature change

There is strong agreement that temperature has increased in Europe and Central Asia over the last sixty years, (**Figure 4.53**), especially after 1980, both for summer and winter average temperatures. The increase for 1950-2016 is significant for almost all of Europe and Central Asia, and was generally higher in winter (specifically in the Arctic Ocean and in Eastern Europe) than in summer, but was higher in summer in the south of Western Europe and Central Asia (see **Figure 4.54**).

The increase in temperatures was significant for all units across Europe and Central Asia, with positive trends of 0.15-0.30°C per decade for summer, and 0.10-0.45°C per decade for winter (see **Figure 4.55**). Increases in temperature were larger in winter than in summer for most units of analysis, except for southern biomes (Mediterranean, subtropical forests, temperate grasslands and deserts in Western Europe and Central Europe. All increases were significant except for winter temperatures of southern units in Western Europe, Central Europe and Eastern Europe.

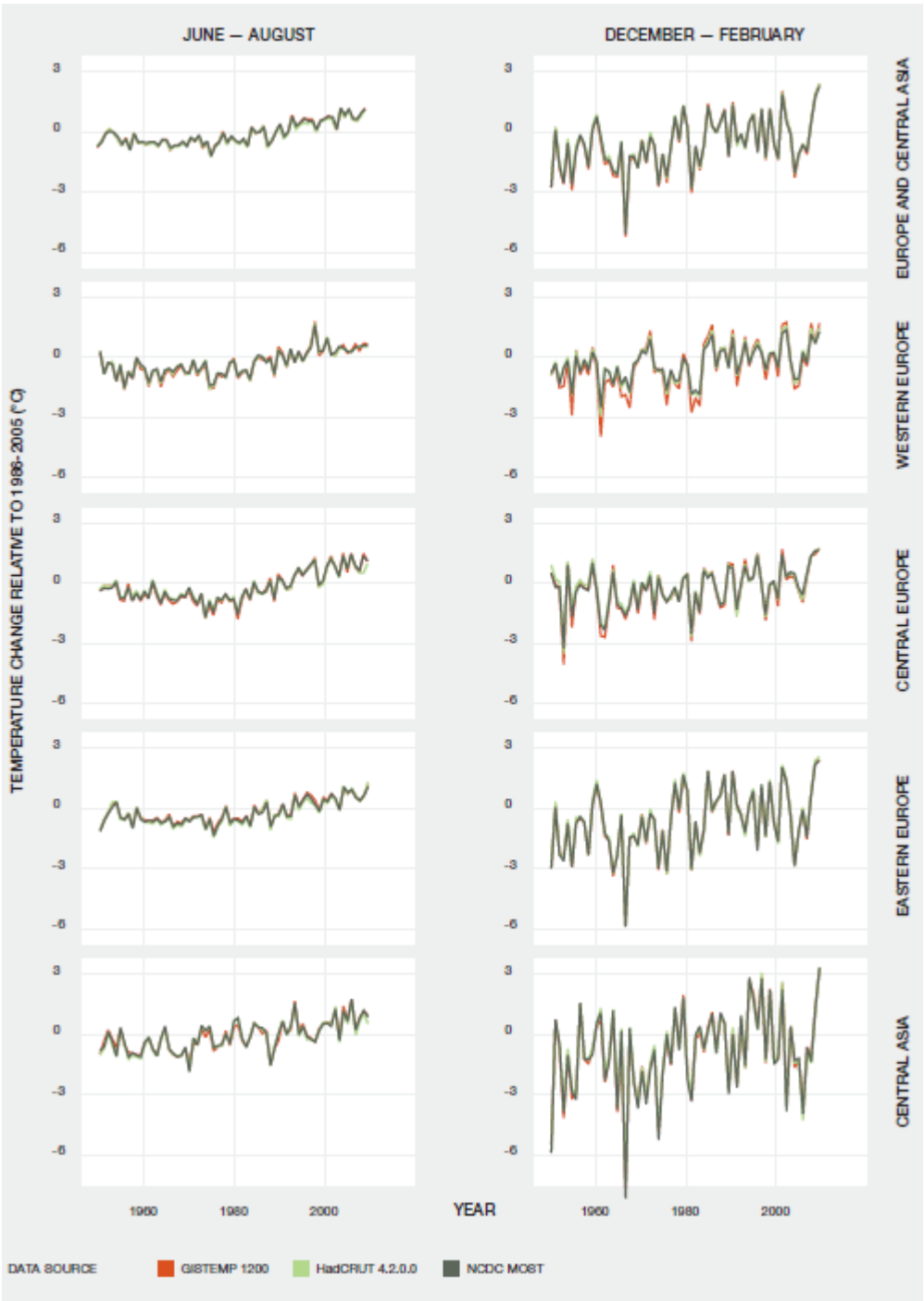


Figure 4.52: Observed annual mean temperature (°C) trends from 1950 to 2016, relative to mean temperatures for 1986-2005, for summer (June to August) and winter (December to February) across Europe and Central Asia, plotted for three datasets: GISTEMP 1200, HadCRUT 4.2.0.0 and NCDC MOST (see Section 4.2.5).

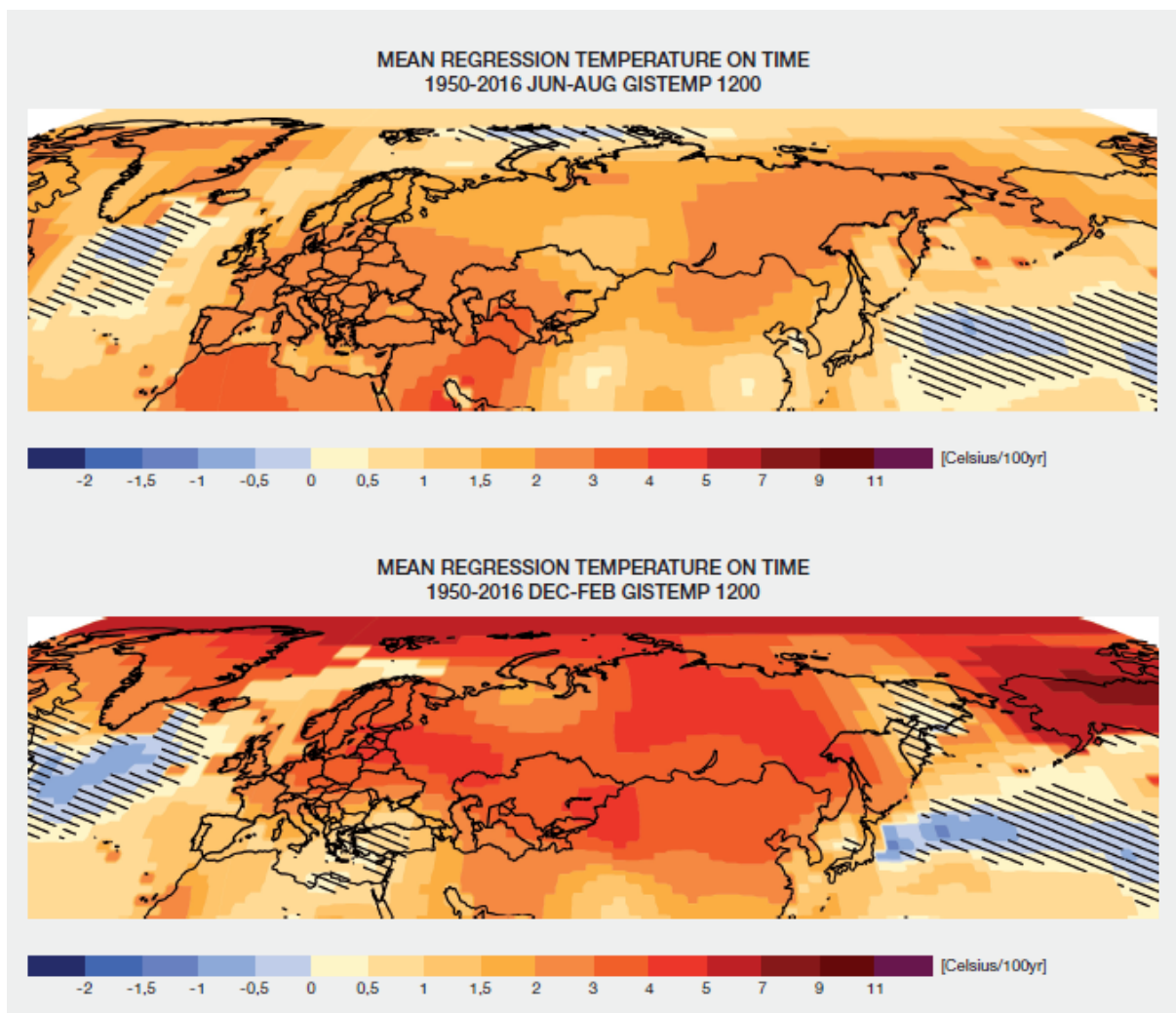


Figure 4.53: Map of observed (linear) temperature ($^{\circ}\text{C}$ / 100 years) trends between 1950 and 2016, for summer (June to August) and winter (December to February) throughout Europe and Central Asia. Only the GISTEMP dataset is presented here (see 4.2.5.1). The hatching represents areas where the estimated trend is less than one standard deviation away from zero (see Hartmann et al., 2013).

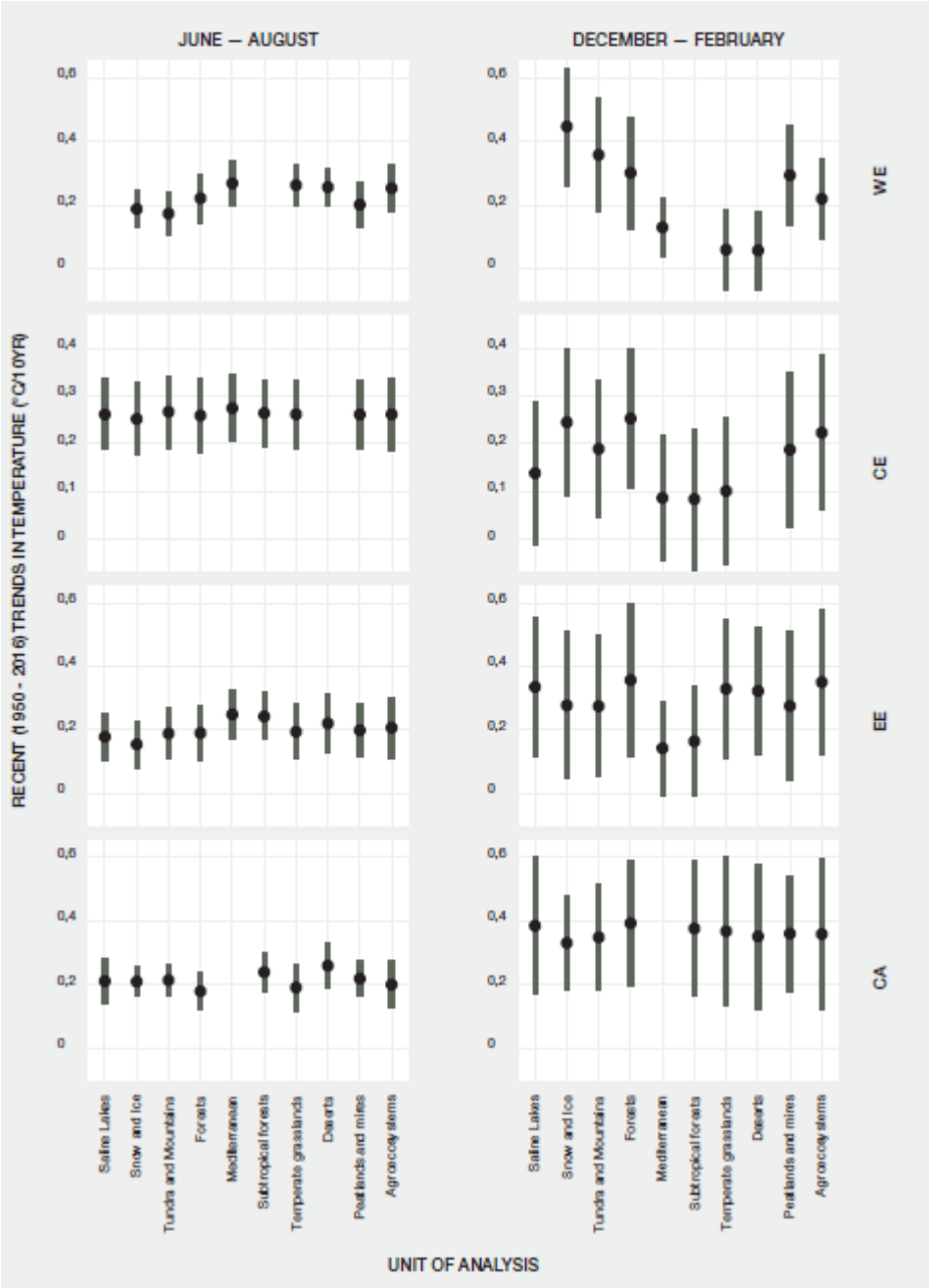


Figure 4.54: Historical temperature trends (1950-2016) for units of analysis in Europe and Central Asia. The calculated linear trend is expressed in °C change/decade (see Hartmann et al., 2013). Colour bars represent 90% confidence intervals around trend estimates. If 90% confidence intervals cross the dashed line of zero, the estimated trend is considered statistically insignificant. Units of analysis are saline Lakes; snow and ice (snow and ice-dominated systems (everything north of or higher than alpine); tundra and mountains (tundra and mountain grasslands (only high elevation grasslands)); forests (broad-leaved, mixed and coniferous forests); Mediterranean (Mediterranean forests, woodlands and scrub); subtropical forests (tropical and subtropical dry and humid forests); temperate grasslands; deserts; peatlands and mires; agroecosystems. WE: Western Europe; CE: Central Europe; EE: Eastern Europe; CA: Central Asia.

Temperature is projected to increase across Europe and Central Asia in all RCP scenarios (Figure 4.55), with 5 to 95% ranges of projected anomalies for 2041-2060 (relative to 1986-2005) for summer ranging from 0.38 to 3.17°C for RCP 2.6 and from 1.28 to 3.72°C for RCP 8.5 (Figure 4.56), and for winter ranging

from 0.18 to 3.92°C for RCP 2.6 and from 2.01 to 5.35°C for RCP 8.5 (Figure 4.56). Increases in temperatures are projected to continue throughout the 2016-2060 period for RCPs 4.5, 6.0, and 8.5, while a plateau is projected for RCP 2.6 after 2040. Summer temperature increases are projected to be higher for southern parts of Western Europe and Central Europe (see Figure 4.56, Figure 4.57) than for other subregions. Winter temperature increases are projected to be largest for Central Asia and Eastern Europe, especially at higher latitudes (Figure 4.56, Figure 4.57).

Temperatures are projected to increase for all units of analysis throughout subregions of Europe and Central Asia (Figure 4.58), with increases in summer being projected similarly among all units according to the CMIP5 ensemble ranging from 1 to 3°C depending on representative concentration pathway scenario, and with increases in winter being projected to differ among biomes. Specifically, snow and ice, and tundra and mountain grasslands have larger projected winter temperature increases (2.5 to 5°C) than the other units of analysis (1 to 3.5°C) in both Western and Eastern Europe.

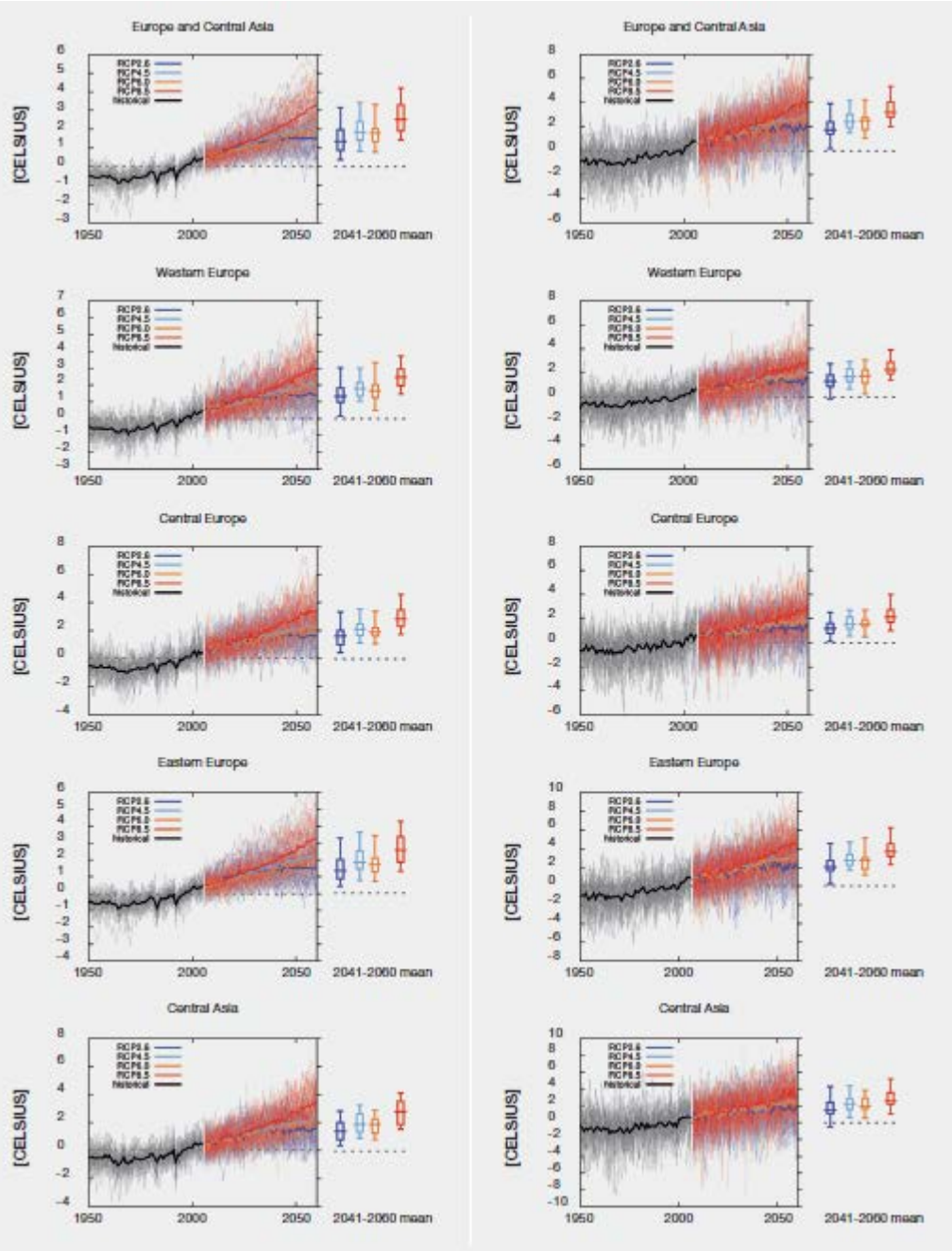


Figure 4.55: Time series of temperature trends relative to 1986-2005 averaged over land grid points for (from top to bottom) Europe and Central Asia, Western Europe, Central Europe, Eastern Europe, and Central Asia in summer (June to August, left panel) and winter (December to February, right panel). Thin lines denote one ensemble member per model and thick lines the CMIP5 multi-model mean (see Figure 4.3 for details). On the right-hand side of each graph the 5th, 25th, 50th (median), 75th and 95th percentiles of the distribution of 20-year mean changes are given for 2041–2060 under the four IPCC RCP scenarios.

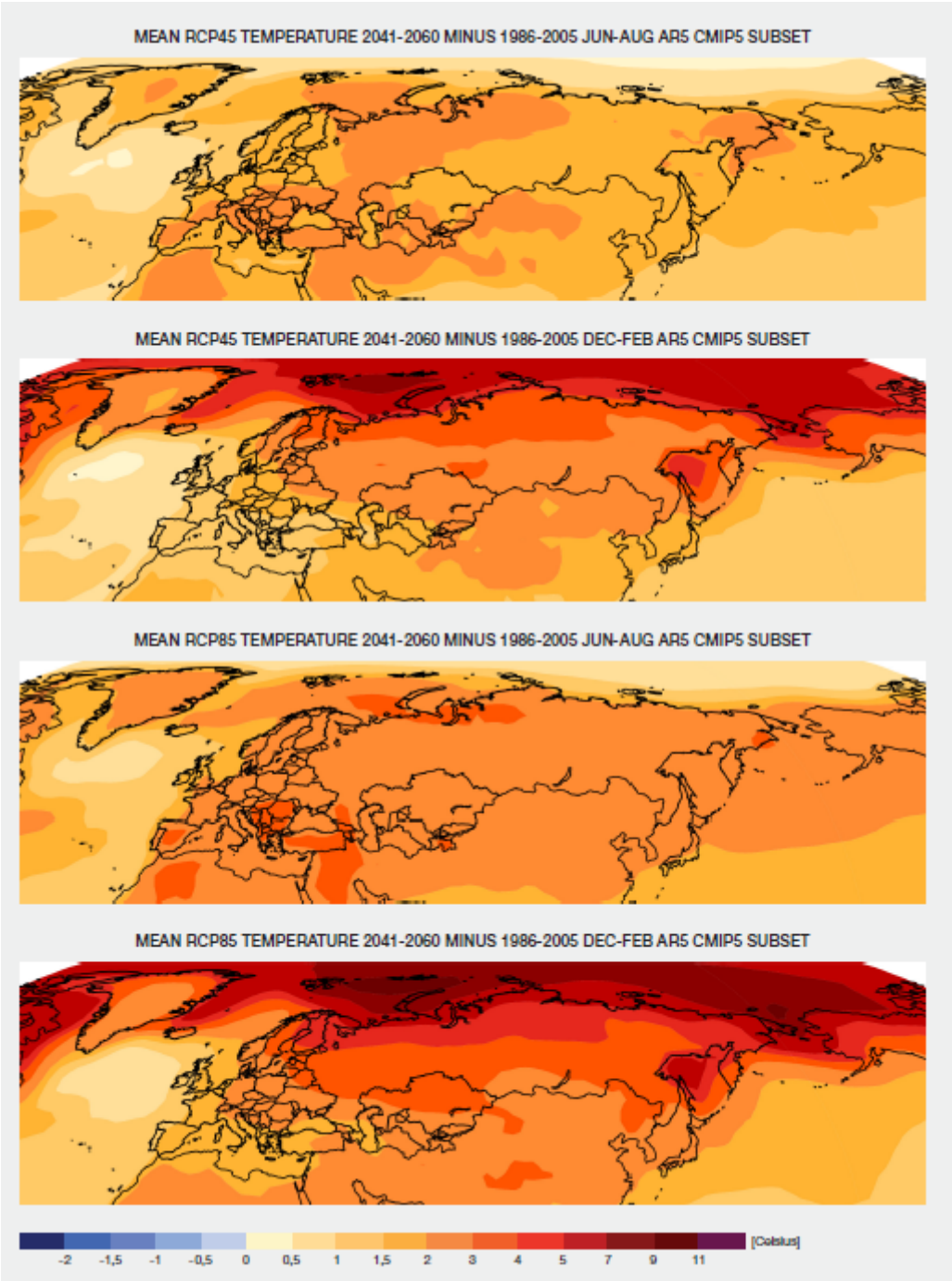


Figure 4.56: Maps of projected (linear) temperature trends by 2041-2060 relative to 1986-2005 under the RCP4.5 (top two panels) and the RCP 8.5 scenario (bottom two panels) for summer (June to August) and winter (December to February). Ensemble means from CMIP5 are presented here, extracted from data of IPCC (2013b).

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Figure 4.57: Projected temperature changes (2041-2060) relative to 1986-2005 averaged over land grid points for units of analysis of Western Europe, Central Europe, Eastern Europe, and Central Asia. Points represent model ensemble means from CMIP5 for each representative concentration pathway (RCP) scenario. Bars represent one standard deviation of natural variability around 1986-2005 means. Units of analysis are saline lakes; snow and ice (snow and ice-dominated systems (everything north of or higher than alpine); tundra and mountains (tundra and mountain grasslands (only high elevation grasslands))); forests (broad-leaved, mixed and coniferous forests); Mediterranean (Mediterranean forests, woodlands and scrub); subtropical forests (tropical and subtropical dry and humid forests); temperate grasslands; deserts; peatlands and mires; agroecosystems.

20912 4.7.2.2 *Precipitation change*

20913 Precipitation has increased only insignificantly over the last sixty years across most of Europe and
20914 Central Asia (see **Figure 4.59**) (Hartmann et al., 2013), with considerable subregional variation (**Figure**
20915 **4.59**). Significant increases and decreases were only detected for some parts within subregions (**Figure**
20916 **4.59**). Winter precipitation has decreased for southern Western Europe and Central Europe. In Eastern
20917 Europe, summer precipitation has in- and decreased in some areas throughout the subregion, whereas
20918 winter precipitation has decreased in eastern, but increased in the western parts of Eastern Europe. In
20919 Central Asia summer precipitation has generally decreased but winter precipitation has increased.

20920 Precipitation trends were generally insignificant for the different units across Europe and Central Asia
20921 (**Figure 4.60**), and only a few significant changes were detected for tundra and mountain grasslands
20922 (winter increase in Western Europe), and saline lakes, temperate grasslands and agroecosystems
20923 (winter increase in Central Asia).

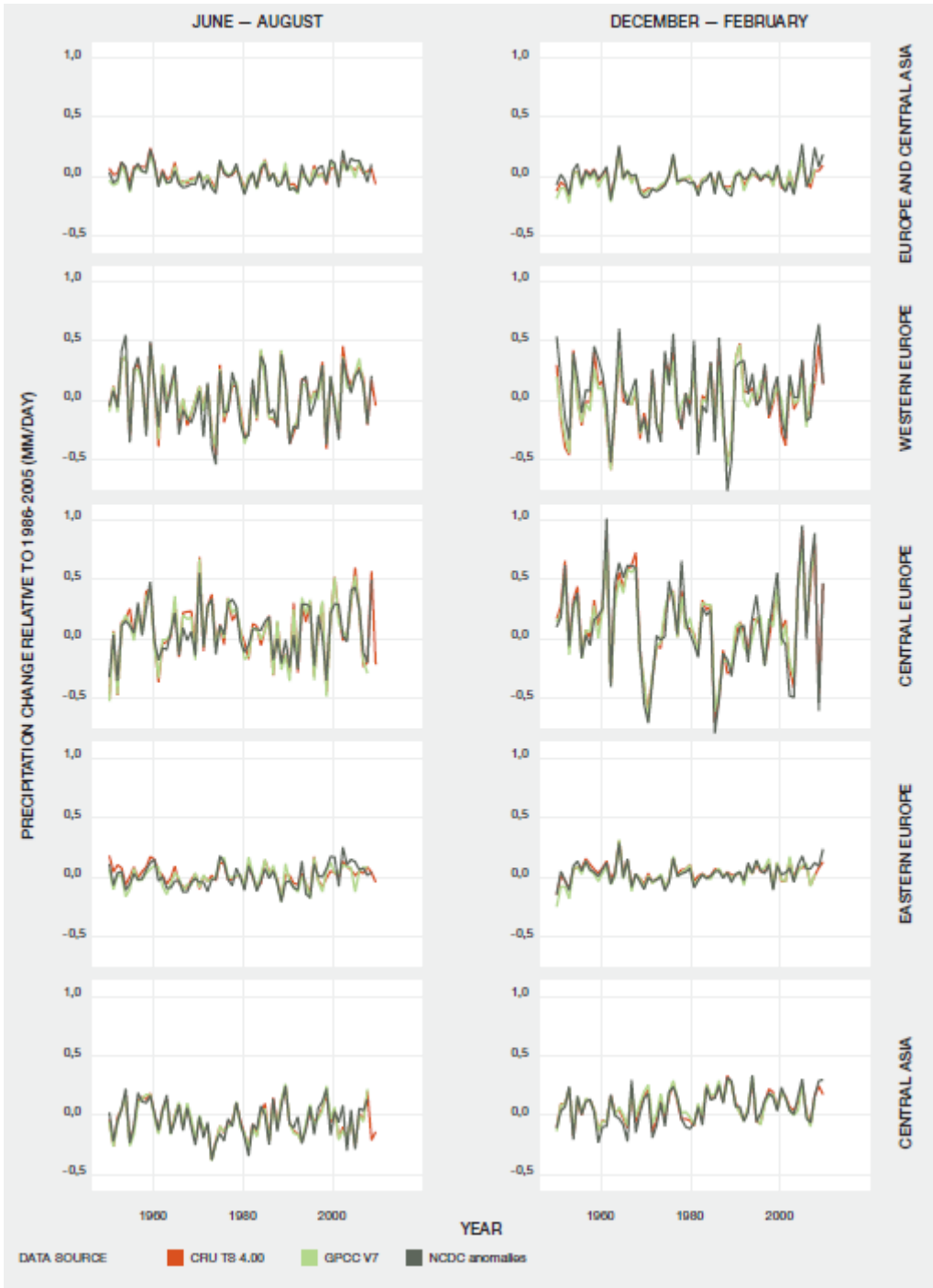


Figure 4.58: Observed precipitation (mm/day) trends from 1950 to 2016, relative to mean precipitation for 1986-2005, for summer (June to August) and winter (December to February) across Europe and Central Asia, plotted for three datasets: CRU TS 4.00, GPCC V7 and NCDC anomalies.

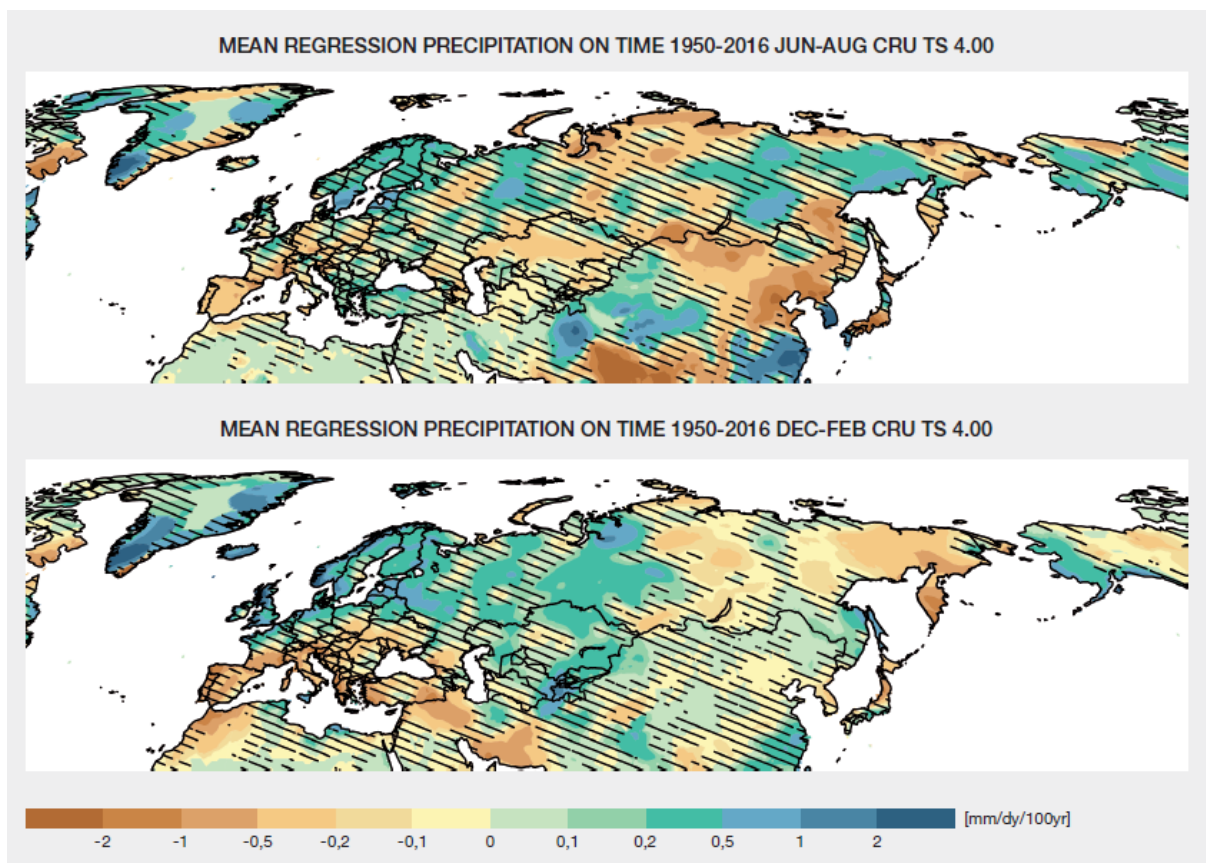


Figure 4.59: Map of observed (linear) precipitation trends (mm/day per 100 year) between 1950 and 2016, for summer (June to August) and winter (December to February) throughout Europe and Central Asia. The CRU TS 4.00 dataset is presented here. The hatching represents areas where the estimated trend is less than one standard deviation away from zero (see Hartmann et al., 2013 for details).

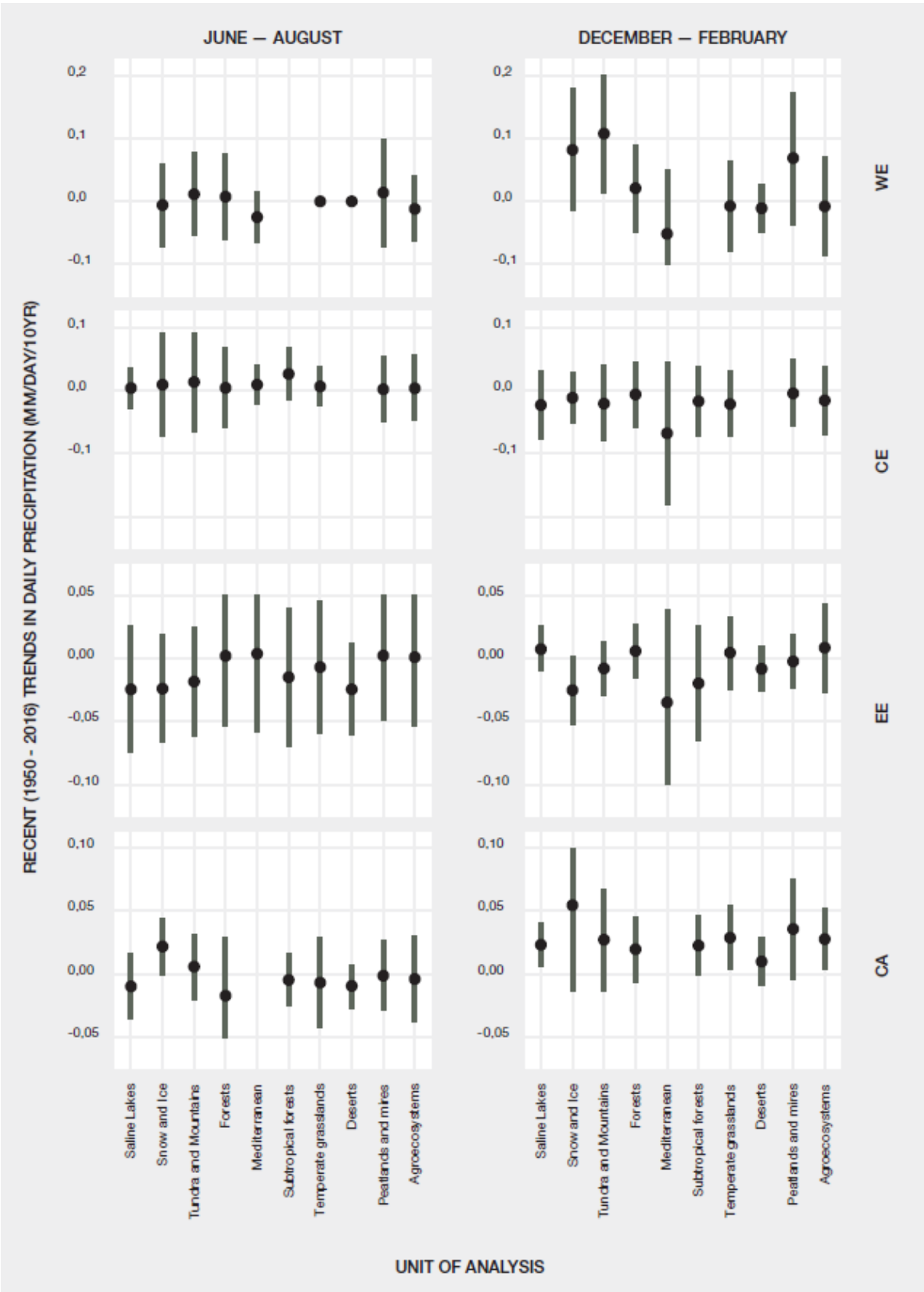


Figure 4.60: Historical precipitation trends (1950-2016) for units of analysis of Europe and Central Asia. The calculated linear trend is expressed in mm/day/decade (Hartmann et al., 2013). Colour bars represent 90% confidence intervals around trend estimates. If 90% confidence intervals cross the dashed line of zero, the estimated trend is considered statistically insignificant. Units of analysis

20941 are saline Lakes; snow and ice (snow and ice-dominated systems (everything north of or higher than
 20942 alpine); tundra and mountains (tundra and mountain grasslands (only high elevation grasslands));
 20943 forests (broad-leaved, mixed and coniferous forests); Mediterranean (Mediterranean forests,
 20944 woodlands and scrub); subtropical forests (tropical and subtropical dry and humid forests);
 20945 temperate grasslands; deserts; peatlands and mires; agroecosystems.

20946 Precipitation is projected to increase in future across Europe and Central Asia according to all RCP
 20947 scenarios (see **Figure 4.62**), yet with important uncertainties. Increases are projected to be larger for
 20948 winter than for summer. Summer precipitation anomalies for 2041-2060 relative to 1986-2005 for RCP
 20949 2.6 range from -0.06 to 0.24mm/day and for RCP 8.5 range from -0.07 to 0.21mm/day (5 to 95%) (see
 20950 **Figure 4.62**). Projected winter precipitation anomalies for 2041-2060 relative to 1986-2005 for RCP 2.6
 20951 range from 0 to 0.21mm/day and for RCP 8.5 range from 0.05 to 0.23mm/day (5 to 95%) (see **Figure**
 20952 **4.62**).

20953 At a subregional scale, most projected precipitation changes fall within one standard deviation of the
 20954 natural variability over much of Europe and Central Asia (see **Figure 4.62**). For summer, significant
 20955 increases in precipitation are projected for northern areas of Western Europe and Eastern Europe, and
 20956 decreases in southern parts of Western Europe (see **Figure 4.62**), in accordance with Kirtman et al.
 20957 (2013). For winter, increases in precipitation are projected over Eastern Europe, Central Asia, and in
 20958 northern parts of Western Europe (see **Figure 4.62**).

20959 Changes in summer precipitation are projected for most units of analysis throughout Europe and
 20960 Central Asia except for deserts (**Figure 4.63**). Changes in winter precipitation are projected for almost
 20961 all units in Western Europe, Eastern Europe and Central Asia, whereas projected changes for Central
 20962 Europe are less clear with values projected within natural variability range depending on scenarios
 20963 (**Figure 4.63**). Specifically, in Western Europe, changes (increases and decreases, depending on units)
 20964 are projected for both summer and winter precipitation. In Central Europe, decreases are projected
 20965 for all units for summer precipitation, whereas projected changes are variable among units for winter.
 20966 In Eastern Europe, increases are projected for most units for both summer and winter precipitation,
 20967 except for summer precipitation in Mediterranean and subtropical forest units, which is projected to
 20968 decrease. In Central Asia, increases are projected for all biomes for winter precipitation only.

20969 In summary, precipitation will very likely change throughout Europe and Central Asia, will likely
 20970 increase for most units of analysis in Eastern Europe and Central Asia and for northern units in Western
 20971 Europe, and likely decrease for southern units in Western Europe and Central Europe.

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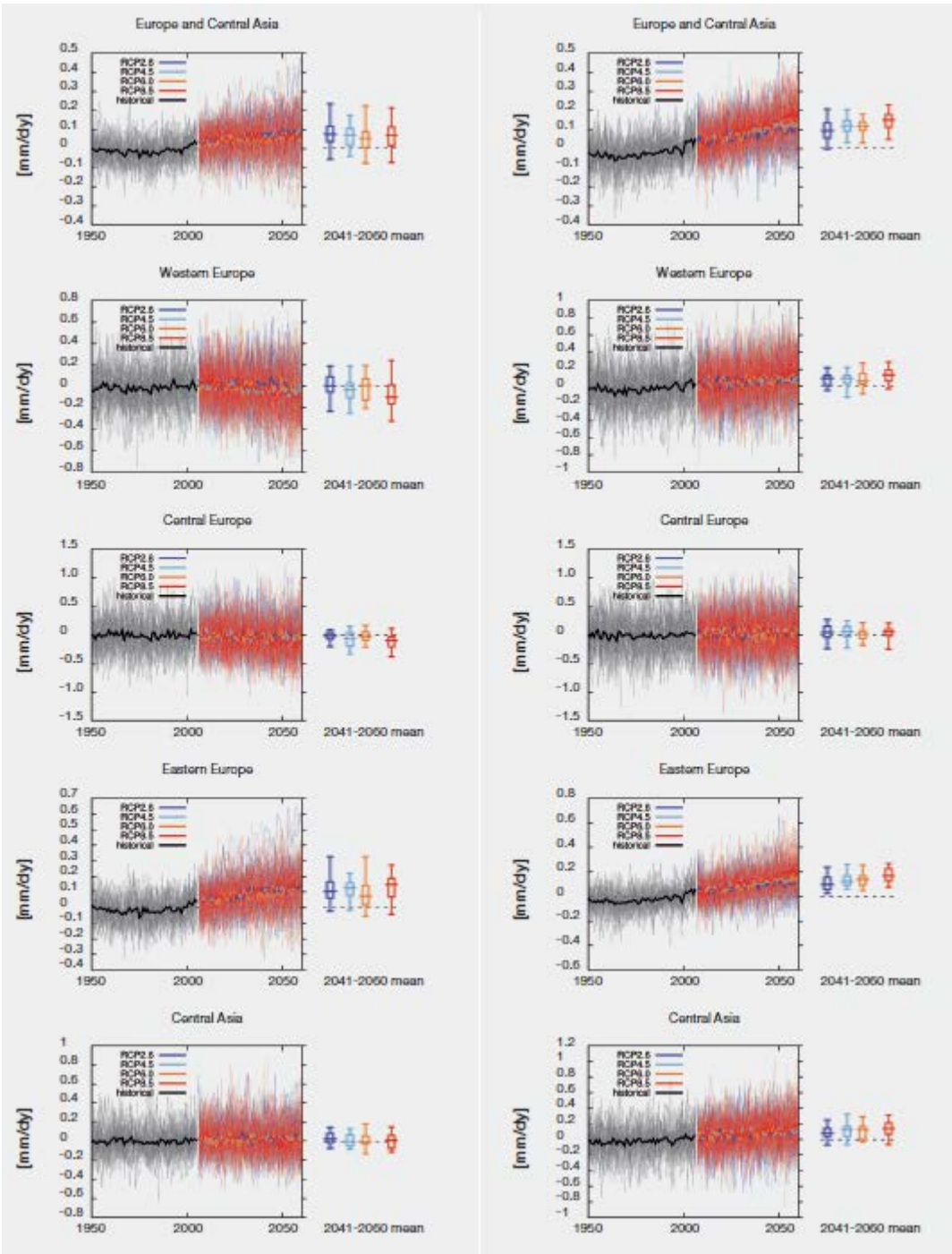


Figure 4.61: Time series of precipitation trends relative to 1986-2005 averaged over land grid points for (from top to bottom) Europe and Central Asia, Western Europe, Central Europe, Eastern Europe, Central Asia in summer (June to August, left panel) and winter (December to February, right panel). Thin lines denote one ensemble member per model and thick lines the CMIP5 multi-model mean (see Figure 4.3 for details). On the right-hand side of each graph the 5th, 25th, 50th (median), 75th and 95th percentiles of the distribution of 20-year mean changes are given for 2041–2060 under the four IPCC representative concentration pathway (RCP) scenarios.

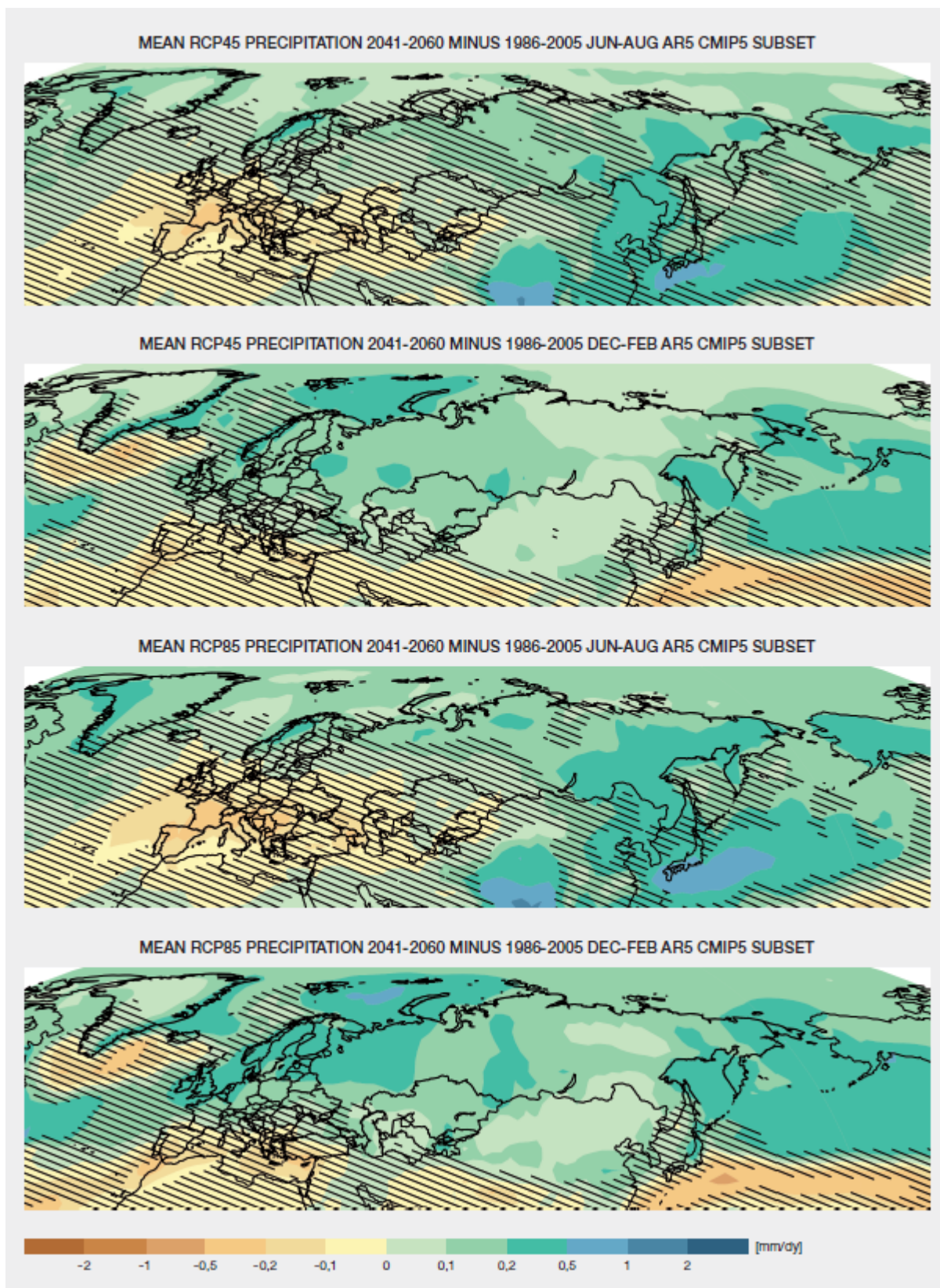
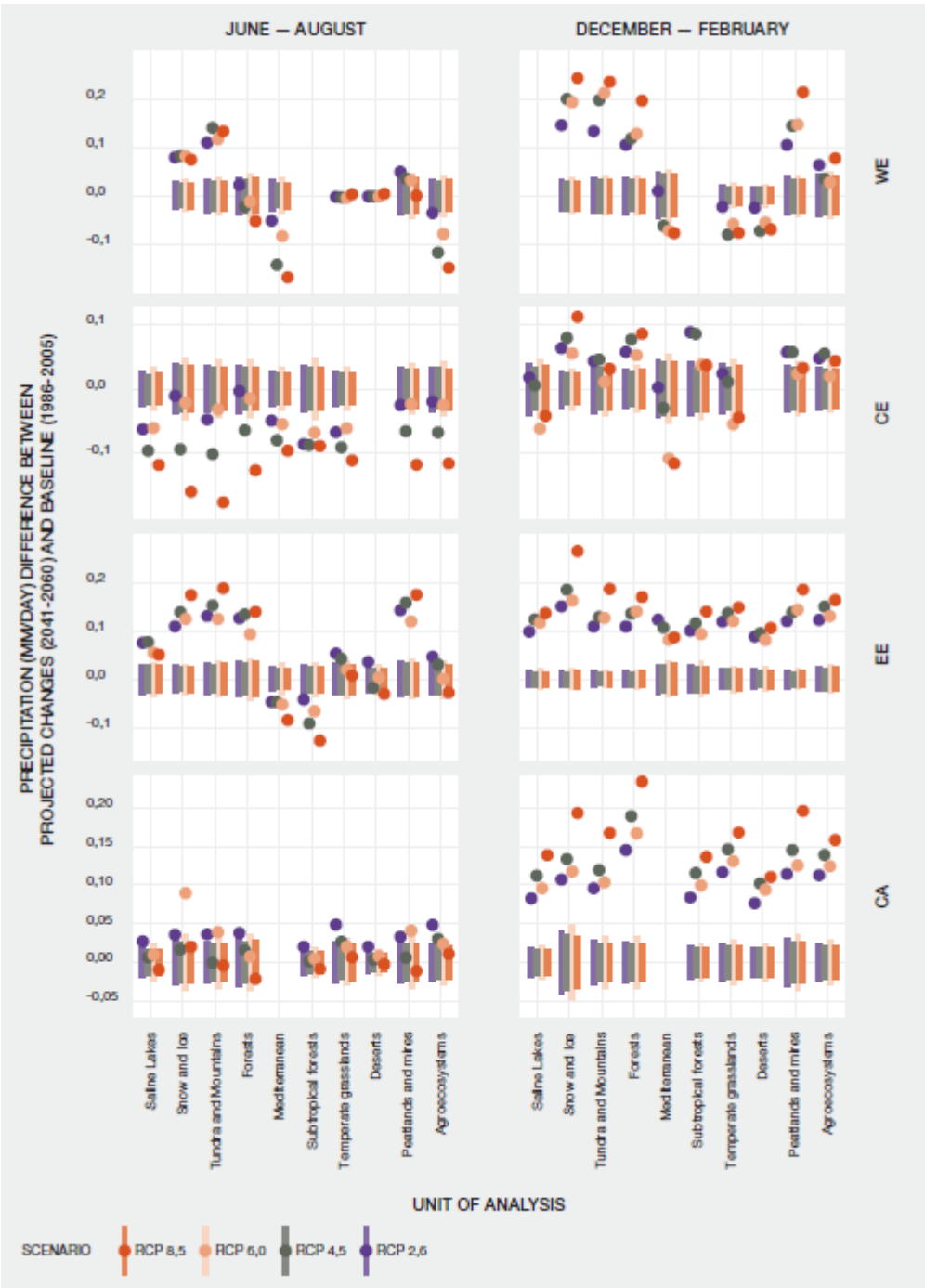


Figure 4.62: Maps of projected (linear) precipitation trends by 2041-2060 relative to 1986-2005 under the RCP4.5 (top two panels) and the RCP 8.5 scenario (bottom two panels) for summer (June to August) and winter (December to February). Ensemble means from CMIP5 are presented here, extracted from data of IPCC (2013b).

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Figure 4.63: Projected precipitation changes (2041-2060) relative to 1986-2005 averaged over land grid points for units of analysis of Europe and Central Asia, Western Europe, Central Europe, Eastern Europe, Central Asia. Points represent model ensemble means from CMIP5 for each representative concentration pathway (RCP) scenario. Bars represent one standard deviation of natural variability around 1986-2005 means. Units of analysis are saline lakes; snow and ice (snow and ice-dominated systems (everything north of or higher than alpine); tundra and mountains (tundra and mountain grasslands (only high elevation grasslands)); forests (broad-leaved, mixed and coniferous forests); Mediterranean (Mediterranean forests, woodlands and scrub); subtropical forests (tropical and subtropical dry and humid forests); temperate grasslands; deserts; peatlands and mires; agroecosystems.

4.7.2.3 Sea-level change

The sea-level has risen ca. 150 mm in the past century. Recent trends in sea-level rise are uniform across the globe. Eastern Europe and Central Asia are exceptional because of the Caspian Sea, where sea-level change is decoupled from global sea-level rise and trends are uncertain. The Caspian Sea level decreased throughout the first half of the previous century, and subsequently increased to almost re-reach its historical level (Arpe & Leroy, 2007; Leroy, Marret, Giralt, & Bulatov, 2006 and references therein).

In the future sea-level is projected to continuously increase globally (Figure 4.65) due to various reasons, including temperature induced swelling and melting land ice, to reach a total increase by 2100 of 0.3-1 m (IPCC, 2013b). Sea level changes in the Caspian Sea will most likely depend on the projected precipitation regimes of its watershed (Arpe & Leroy, 2007), which are least certain but potentially increase, while fluctuations may be extreme (Roshan, Moghbel, & Grab, 2012).

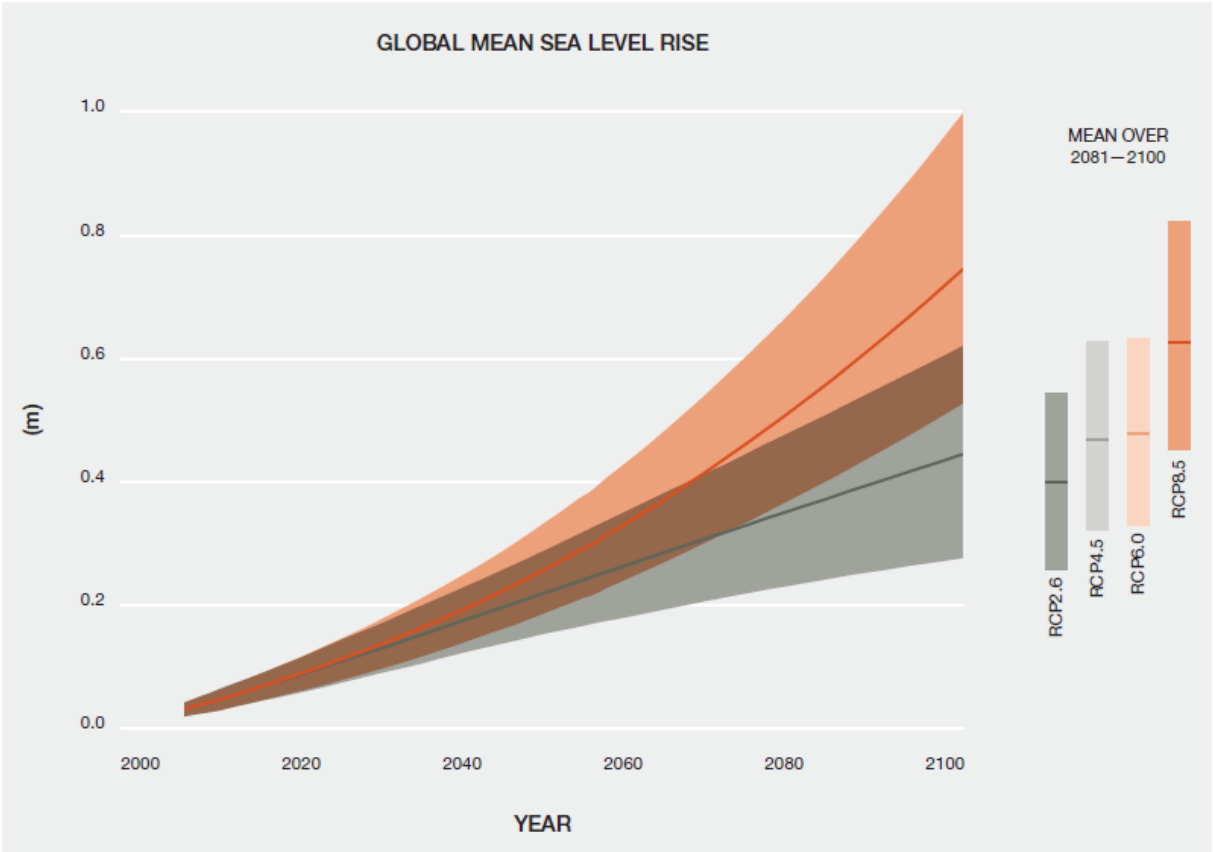


Figure 4.64: Projected sea level rise according to the different representative concentration pathways (RCP) used in the 5th assessment report of the Intergovernmental Panel on Climate Change.

While coastal habitats and estuaries experience strong effects from rise in sea-level, benthic habitats are less concerned (only near-shore) and pelagic habitats are least affected. Within the region, a sea-level rise of at least 1m would affect primarily the heavily populated regions in Western Europe (mostly The Netherlands, but also Germany, Denmark and UK), where a rise of 1-5 m (Figure 4.66) would affect up to 22 million inhabitants. A realistic sea level rise of just 1m would affect almost the same amount of land, biomes and people as a 5m rise. Such drastic shifts will have a strong effect on coastal ecosystems, on sessile and migrating animals (birds), and on the structuring of the coastal biomes.

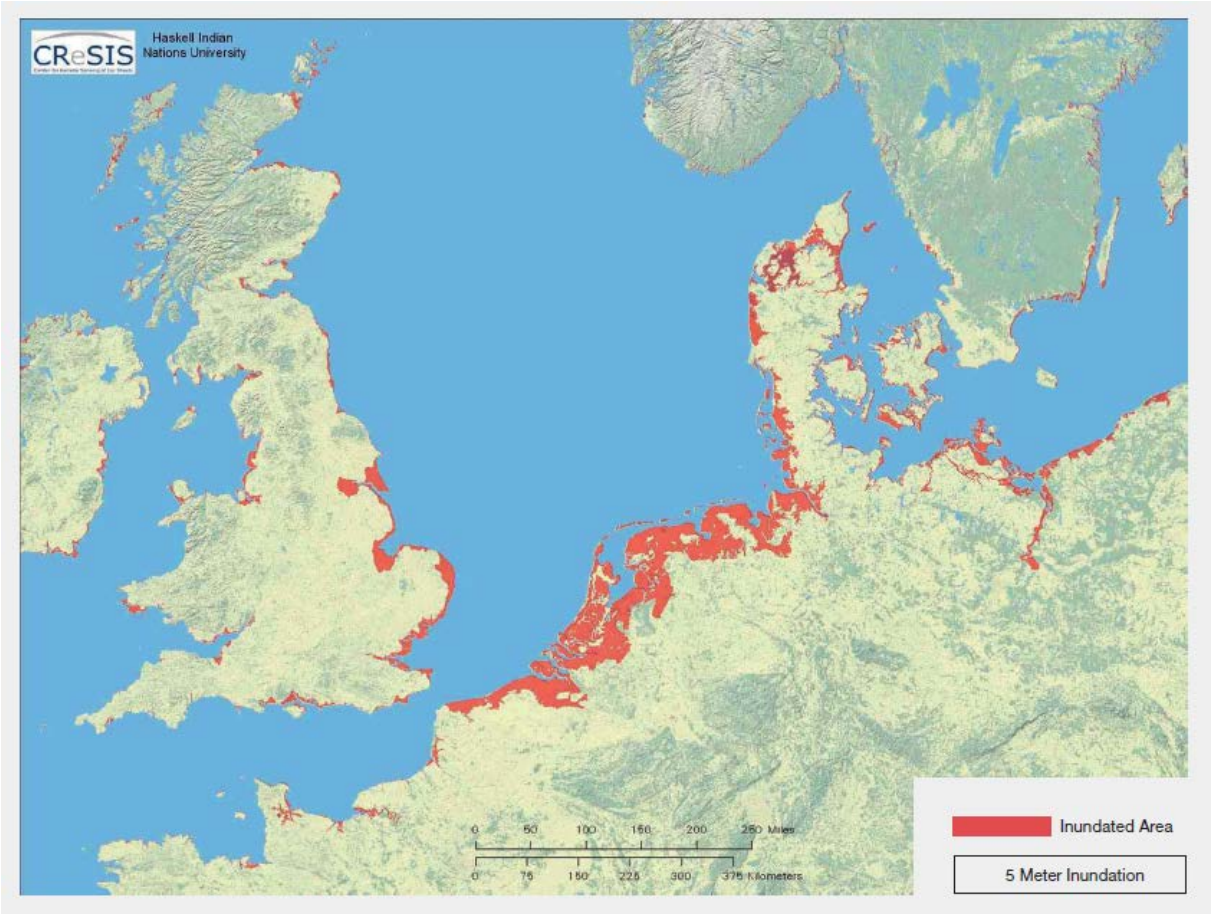


Figure 4.65: Projected impact from a sea level rise (5 m) for north-western Europe. A population of 21.7 million is calculated to be at risk in the inundation area (Rowley et al., 2007).

4.7.2.4 Trends in glaciers and permafrost

4.7.2.4.1 Glacier melting

There is high general confidence that current glacier extents are out of balance due to increased recent temperatures, indicating that glaciers will continue to shrink in the future even without further temperature increase (Hagen, Liestøl, Roland, & Jørgensen, 1993; IPCC, 2013b). The average rate of ice loss from glaciers around the world (including both Alpine and Arctic glaciers), excluding glaciers on the periphery of the ice sheets, was very likely 226 [91 to 361] Gt yr⁻¹ over the period 1971 to 2009, 275 [140 to 410] Gt yr⁻¹ over the period 1993 to 2009 and 301 [166 to 436] Gt yr⁻¹ between 2005 and 2009 (IPCC, 2013b). Most glaciers around the globe have been shrinking since the end of the Little Ice Age (ca. 1300-1850), with increasing rates of ice loss since the early 1980s.

There is, however, regional variation and also wide variation within regions related to precipitation patterns, altitudinal range, area distribution and dynamic responses. For instance, in the Jotunheimen region, the highest mountain massif in Norway, the general trend (based on Landsat TM/ETM+ data from 2003) is glacier recession, while some glaciers in that region increased their size or remained nearly unchanged over these decades (Andreassen, Paul, Kääb, & Hausberg, 2008). Another example is the Svartisen region in Norway, where the overall glacier area changed from 1968 to 1999 was close to zero, but where there was a stronger relative area loss towards the wetter coast (Paul & Andreassen, 2009). Generally, the investigated glaciers in the Jotunheimen region shrank since the 1930s, with an

overall area reduction of about 23% for 38 glaciers. Since the 1960s the area reduction for 164 glaciers in that region was 12% (c. 3.2% per decade) and since 1980 3% per decade. The 3.2% per decade reduction in glacier area since 1965 and 3% since 1980 in Jotunheim is comparable to other parts of the region with mountain and valley glaciers. In the Swiss Alps, the area change was –2.2% per decade for the period 1850-1973 and –6.4% per decade for the period 1973-1999 (Paul, Kääb, Maisch, Kellenberger, & Haeberli, 2004). In the Jostedalsbreen region, Norway, there was an area loss of 2.3% per decade in the period 1966-2006 (Paul, Andreassen, & Winsvold, 2011). Inventory results from the Austrian Alps show a net reduction of glacier area of 17% between 1969 and 1998 (Lambrecht & Kuhn, 2007), or –6% per decade. In southern Spitsbergen, most glaciers – whether tidewater or land-terminating, large or small, debris-covered or comparatively clean ice types – have undergone retreat, both over the period 1936-1990 (832.5 km²) and 1990-2008 (243.1 km²). In the latter period, the glacier area change was on average around –3% per decade (König, Nuth, Kohler, Moholdt, & Pettersen, 2014). Also in other parts of Svalbard, glacier area has been decreasing substantially during the past 50 years (Hagen et al., 1993). In the Russian High Arctic, the archipelagos have lost ice at a rate of –9.1 ± 2.0 Gt per year, which corresponds to a sea level contribution of 0.025 mm per year. Approximately 80% of the ice loss came from Novaya Zemlya with the remaining 20% coming from Franz Josef Land and Severnaya Zemlya (Moholdt, Wouters, & Gardner, 2012). In the Tien Shan (in the border region of Kazakhstan, Kyrgyzstan and north-western China) the area reduction was 32% between 1955 and 1999 (Bolch, 2007), or – 9% per decade.

4.7.2.4.2 Permafrost thawing

There is agreement that near-surface permafrost extent at high northern latitudes will be reduced as global mean surface temperature increases. By the end of the 21st century, the area of permafrost near the surface (upper 3.5 m) is projected to decrease by between 37% (RCP2.6) and 81% (RCP8.5) for the model average (IPCC, 2013b). Permafrost temperatures have increased, and the depth of seasonally frozen ground has become reduced, in most regions since the early 1980s, although the rate of increase has varied regionally. Also, the temperature increase for colder permafrost was generally greater than for warmer permafrost. Significant permafrost degradation has occurred in the Russian European north, where observed warming was up to 2 °C in the period 1971 - 2010 (Malkova, 2008; Oberman, 2008, 2012; Romanovsky et al., 2010). In the latter region, a considerable reduction in permafrost thickness (up to 15 m) and areal extent (poleward shift up to 80 km for discontinuous and up to 50 m for continuous permafrost extent) has been observed over the period 1975 to 2005 (IPCC, 2013b).

In northern Yakutia (Russia), permafrost temperatures have warmed by 0.5-1.5 °C between the early 1950s and 2009 (Romanovsky et al., 2010), and in the Trans-Baykal region (Russia) by 0.5-0.8 °C between the late 1980s and 2009 (Romanovsky et al., 2010). In Tian Shan, permafrost temperature has increased by 0.3-0.9 °C during 1974-2009 (Marchenko, Gorbunov, & Romanovsky, 2007; Zhao, Wu, Marchenko, & Sharkhuu, 2010). In the Alps, permafrost temperatures have increased by 0.0 – 0.4 °C in the period 1990-2010 (Christiansen et al., 2012; Haeberli et al., 2010; Noetzli & Mühll, 2010), and in the Nordic countries by 0.0-1.0 °C during 1999-2009 (Christiansen et al., 2010; Isaksen et al., 2011). The thickness of the seasonally frozen ground in some non-permafrost parts of the Eurasian continent likely decreased, in places by more than 30 cm from 1930 to 2000.

4.7.2.5 Trends in extreme events

4.7.2.5.1 Drought and temperature extremes

In recent decades, drought and heat waves have increased in Western and Central Europe, while showing a north-south gradient in both subregions (drier in the south, no change or moister in the north, L. V. Alexander et al., 2006; Kiktev, Sexton, Alexander, & Folland, 2003; Sheffield & Wood, 2008a). These recent trends for Western, Central, and Eastern Europe are considered likely, while trends in Central Asia are as likely as not (IPCC, 2012). Drought is often associated with extreme heat waves, which can stretch over large regions, and which may result in punctuated drought events (Figure 4.67).

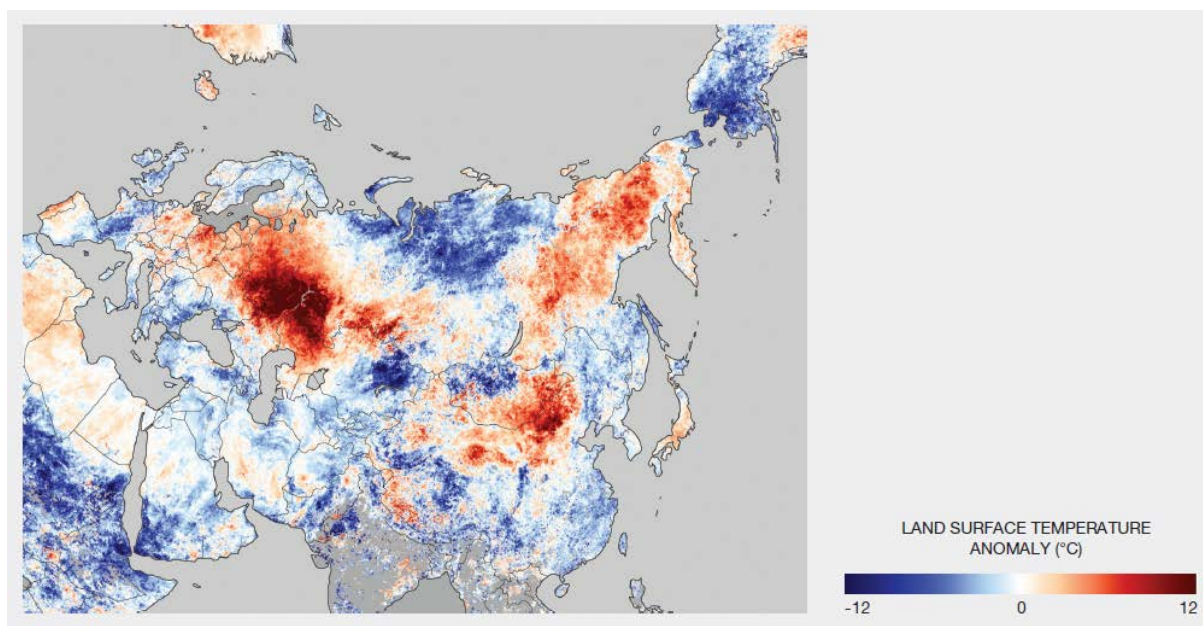


Figure 4.66: Russian heat wave in 2010, which has stretched over large parts of Eastern Europe and affected also Central Europe and Central Asia. Image derived from NASA. Colours indicate the degree of positive (red, hotter) or negative (blue, colder) deviations from July 20-27, 2010 compared to the average temperature of the same dates over the measurement period 2000-2008, as obtained by the MODIS Earth Observation Satellite. Source: <https://earthobservatory.nasa.gov/IOTD/view.php?id=45069>.

Projected trends in drought are considered very likely in Western and Central Europe since projections are in high agreement (drier in the south, no change or moister in the north, L. V. Alexander et al., 2006; Kiktev et al., 2003; Sheffield & Wood, 2008b), while for Eastern Europe and Central Asia the projected trends are about as likely as not. Generally, the largest increase in the duration and intensity of drought periods is projected for Mediterranean climate zones (Beniston et al., 2007; May, 2008), while for northern parts of Western Europe only moderate or no increase in drought is expected (IPCC, 2012), so this trend is as likely as not. Future trends for Eastern Europe vary between projections, but also spatially, with potentially less drought in northern parts of Eastern Europe (Dai, 2011; Sillmann & Roeckner, 2008). Seasonality in drought events is also expected to change throughout Europe and Central Asia (Orlowsky & Seneviratne, 2012).

21115 4.7.2.5.2 Floods

21116 Recent trends in floods are very difficult to assess because of a lack of long time-series of gauge-
 21117 stations and because floods are rare. Therefore, flood assessments of the recent past are least certain
 21118 and without a directional trend throughout Europe and Central Asia (IPCC, 2012).

21119 Projections of floods are to a large degree based on projections of heavy precipitation events which,
 21120 in turn, are based on physical reasoning, but changes in snow accumulation and the timing of snow-
 21121 melt potentially also contribute to flood-risk projections. However, the magnitude of this contribution
 21122 is uncertain (IPCC, 2012). Heavy precipitation is expected to increase in Western and Central Europe,
 21123 with highest certainty and magnitude in the north while Mediterranean Europe may not experience
 21124 the associated increase in flood risk (Beniston et al., 2007)(Frei, Schöll, Fukutome, Schmidli, & Vidale,
 21125 2006)(Kendon, Rowell, Jones, & Buonomo, 2008). While the trend is consistent between summer and
 21126 winter, the magnitude may vary between seasons, but also spatially (Frei et al., 2006; Kendon et al.,
 21127 2008). Coastal regions of Western Europe may be exposed to north-shifted extra-tropical cyclones
 21128 (IPCC, 2012) and thus be under increased flooding risk. Increased frequency of heavy precipitation
 21129 events is highly certain in Eastern Europe (IPCC, 2012)³⁷, while for Central Asia projections are partly
 21130 contradictory resulting overall in no projected increase of heavy precipitation, but with least certainty
 21131 (IPCC, 2012).

21132

21133 4.7.2.5.3 Fire

21134 An observed global increase in fire frequency and burnt area is most likely driven by climate (Marlon
 21135 et al., 2008). Fires have generally increased in recent decades in the Mediterranean area (EEA, 2012a;
 21136 Pausas, 2004). Forest fires have also generally increased in Europe and Central Asia (Schelhaas,
 21137 Nabuurs, & Schuck, 2003), with highest increases in the southern parts of Western, Central and Eastern
 21138 Europe (EEA, 2012a), while the boreal forest in the north of the Europe and Central Asia region does
 21139 not show increased fire frequency (EEA, 2012a; Lehtonen et al., 2014). Trends in frequency of fires in
 21140 Central Asia are less certain, but fires have also generally increased (Goldammer, Davidenko,
 21141 Kondrashov, & Ezhov, 2004). Risk and spread of fire is often a direct consequence of multiple other
 21142 direct drivers, notably of drought, heat, and tree mortality due to insect disturbance (Bigler,
 21143 Kulakowski, & Veblen, 2005; Clark et al., 2016; Gouveia et al., 2016).

21144 Fire danger is projected to increase, especially for the Mediterranean areas of Western and Central
 21145 Europe (Karali et al., 2014; Khabarov et al., 2014), and potentially for large parts of the Alpine Arc (EEA,
 21146 2012a) and boreal forests of Western Europe (EEA, 2012a; Lehtonen et al., 2014). Fire danger
 21147 projections for Eastern Europe and Central Asia are less certain, but increase in fire risk is potentially
 21148 low in the north and moderate in the south of Eastern Europe (Mokhov, Chernokulsky, & Shkolnik,
 21149 2006; Tchebakova, Parfenova, & Soja, 2009), and generally increased in Central Asia (Goldammer et
 21150 al., 2004).

21151

21152 4.7.2.5.4 Windthrow

21153 Trends in windthrow are difficult to assess because they are rare, thus confidence in emerging trends
 21154 is low. Studies consistently report an increase in storms or storminess from 1960 to 1990, yet no long-
 21155 term trend reaching further back in time is available (R. Allan, Tett, & Alexander, 2009; Barring & von
 21156 Storch, 2004; Matulla, Schöner, Alexandersson, von Storch, & Wang, 2008; Schelhaas et al., 2003; X. L.
 21157 Wang, Zwiers, Swail, & Feng, 2009). The number of available studies and the certainty of trend

³⁷ See table 3-3 therein

21158 assessments are highest for Western Europe and lower for Central Europe, Eastern Europe, and Central
21159 Asia

21160 Future projections of extreme winds are highly uncertain (IPCC, 2012). A north-south gradient with
21161 more extreme winds in the north and less extreme winds in the south is projected for Western and
21162 Central Europe (Beniston et al., 2007; McInnes, Erwin, & Bathols, 2011), but the expected poleward
21163 shift of extra-tropical storm tracks (IPCC, 2012) indicates increased extreme winds for Western Europe
21164 in general, and therefore an increase is very likely for coastal habitats. Eastern Europe is projected to
21165 be under increased wind throw risk across most of its range, while Central Asia will likely experience
21166 less extreme winds (Beniston et al., 2007; McInnes et al., 2011).

21167

21168 4.7.2.5.5 Trends in marine circulation and deoxygenation

21169 Among all marine waters in Europe and Central Asia, the Mediterranean Sea could be particularly
21170 vulnerable to climate variations (Turley, 1999) and was identified as a hot spot for climate change
21171 (Giorgi, 2006). It is indeed characterized by very short ventilation and water residence times (70 years)
21172 compared to other oceanic zones (MerMex Group: Durrieu de Madron et al., 2011). This specificity
21173 makes it a marine area where climate variations may strongly and rapidly impact hydrodynamics and
21174 marine ecosystems.

21175

21176 4.7.2.5.6 Ocean warming

21177 From the 1980s to the late 2000s, the surface temperature of the North Atlantic has warmed faster
21178 than the overall northern hemisphere, as is depicted in the Atlantic multi-decadal oscillation index
21179 (www.esrl.noaa.gov/psd/data/timeseries/AMO/). This is also seen in an enhanced warming of the
21180 upper ocean integrated to 700m, with particularly large changes in the eastern Atlantic inter-gyre
21181 region, as well as on the outskirts of the North Atlantic sub-polar gyre (but not in the Nordic Seas).
21182 Hydrological observations showed that the temperature and salinity of the western Mediterranean
21183 deep-water masses have increased by 0.0034C/year and 0.0011psu/year between 1959 and 1997
21184 (Bethoux, Gentili, & Tailliez, 1998). Numerical studies confirmed that the increase of net atmospheric
21185 heat flux to the sea surface associated to climate change could induce a warming and a salinization of
21186 Mediterranean water masses, in particular at the surface, as well as an intensification of the water
21187 column stratification and a weakening of the thermohaline circulation and winter deep convection
21188 (Adloff et al., 2015; Bozec, 2006; Herrmann et al., 2008; Somot et al., 2006; Thorpe & Bigg, 2000).

21189

21190 4.7.2.5.7 Water masses and horizontal circulation

21191 Climate change has also been identified as cause of weakening and shrinking the North Atlantic sub-
21192 polar gyre and a shift of the sub-polar front (Hatun, 2005). This westward shift of the sub-polar front
21193 implies that the waters in the eastern North Atlantic part of the inter-gyre gyre seem to originate in
21194 recent decades from further south (and get warmer and saltier) than in the 1950-60s. This represents
21195 a shift to more subtropical origin and implies an increased northward flow along Western Europe
21196 (Lozier & Stewart, 2008).

21197 In addition, there is clear evidence from upper temperature and salinity measures of a near decadal
21198 variability in the North Atlantic sub-polar gyre, propagating in a few years all the way through the
21199 Nordic Seas towards the Barents Sea (Yashayaev & Seidov, 2015). Atmospheric forcing or input of cold
21200 and fresh water from the Arctic could contribute to these signals that have been observed since regular
21201 observations began at least 60 years ago. The origin of this ocean variability is debated, and could be

21202 in part natural but also anthropogenically enhanced (for example more North Atlantic oscillation-
 21203 related atmospheric variability, or variable fresh water exports from the Arctic Ocean). It is also
 21204 possible that some of these changes in the warming and vertical structure will reverse, as the Atlantic
 21205 multidecadal oscillations (AMO) shifts to another phase, as has been witnessed twice in the past 120
 21206 years.

21207

21208 4.7.2.5.8 Vertical circulation and mixing

21209 There is debate as to whether the meridional circulation component of the ocean circulation (Atlantic
 21210 Meridional Overturning Circulation) has or has not become stronger during the last century. There is
 21211 accumulating evidence that a slow-down of this circulation is outruled by its large interannual to
 21212 decadal variability, for example induced by wind variability (Rahmstorf et al., 2015). This seems logical,
 21213 based on the expectation that Atlantic Meridional Overturning Circulation intensity is influenced by
 21214 changes in surface water density. Thus, an observed reduction in surface density could result in a
 21215 decrease in Atlantic Meridional Overturning Circulation. A decrease in surface density seems to have
 21216 happened in those areas since 1996 until the early 2010s, as the change due to surface warming was
 21217 not fully compensated by the change due to salinity increase. This is, however, difficult to accurately
 21218 estimate from observations over the relevant time scales.

21219 It is likely that some of these observations and regional patterns of variability might be dependent on
 21220 natural multi-decennial variability such as the North Atlantic oscillation, but there are fewer
 21221 observations to support this. However, these long time-scale trends can be interrupted as the result
 21222 of intense vertical mixing in individual years, such as in 2005 in the Bay of Biscay (Somavilla, González-
 21223 Pola, Schauer, & Budéus, 2016). Clearly, there is also a very large year-to-year variability as the result
 21224 of surface forcing in the eastern Atlantic north of 35-40°N.

21225

21226 4.7.2.5.9 Ocean acidification

21227 The uptake of increased anthropogenic CO₂ is causing profound changes in seawater chemistry
 21228 resulting from increased hydrogen ion concentration (decrease in pH) referred to as ocean acidification
 21229 (IPCC, 2013b). Repeated hydrographic sections provide an understanding of these changes in the
 21230 basin-wide seawater CO₂ chemistry over multi-decadal timescales. The formation of “North Atlantic
 21231 deep water” makes the Atlantic unique with regards to the depths to which anthropogenic CO₂ can
 21232 penetrate over these time scales, reaching the bottom at about 3,000 m in the far north of the North
 21233 Atlantic (Wanninkhof et al., 2010). Here, the ocean acidification signal adds to that of temperature. As
 21234 a consequence, the lysocline, i.e. the depth in the ocean below which the rate of dissolution of calcite
 21235 increases dramatically, could be shallower in polar regions while the decreased rate of pH is expected
 21236 to be similar to the other latitudes.

21237 A recent estimate suggests that all water masses in the Mediterranean Sea are also already acidified (-
 21238 0.14 to -0.05 pH units; Touratier & Goyet, 2011). Considering the highest values of this range, the
 21239 Mediterranean Sea appears to be one of the most acidified marine basins in the world. Yet, as far as
 21240 we know, no estimates of future acidification rates in the Mediterranean Sea have been carried out.

21241

21242 4.7.2.6 Trends in atmospheric CO₂ concentration

21243 The atmospheric concentration of CO₂ is rising with the well-known seasonal pattern, and this trend is
 21244 accelerating steadily (IPCC, 2013b). While from 1965-1974 the atmospheric CO₂ concentration

increased by 1.06 ppm/yr, this increase has reached 2.11 ppm/yr for the decade 2005-2014, and in 2013 the level of 400 ppm of atmospheric CO₂ concentration was reached (IPCC, 2013b) for the first time since about 23 million years ago (Pearson & Palmer, 2000). This steady increase in atmospheric CO₂ affects the ocean surface partial CO₂ pressure, and the increase of this partial pressure reduces the ocean pH, leading to steady acidification (Figure 4.68), and the trend is expected to continue over the 21st century (Figure 4.68).

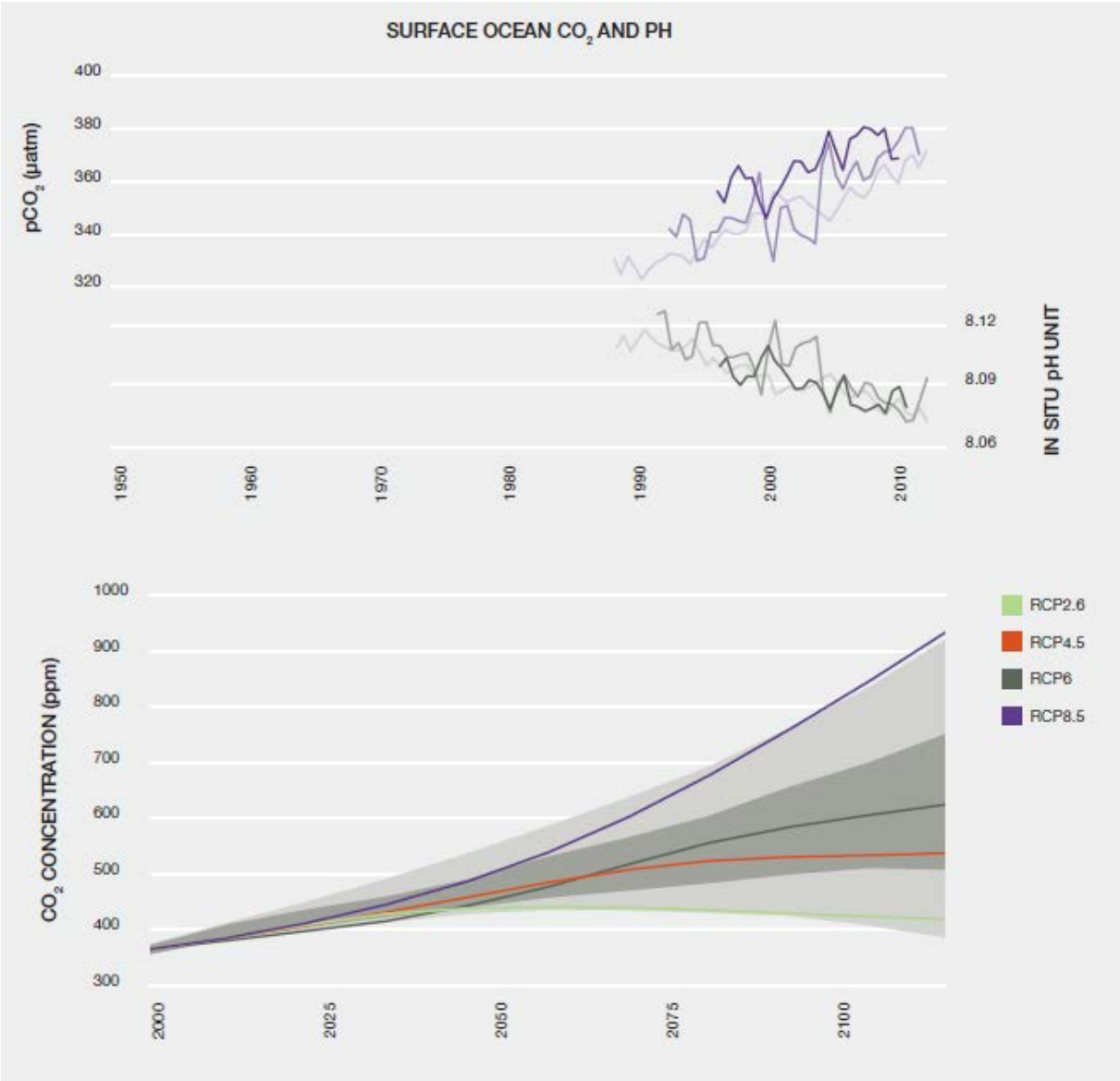


Figure 4.67: Top: Partial pressure of dissolved CO₂ at the ocean surface (violet, upper curves) and in situ pH (grey curves), a measure of the acidity of ocean water recorded in three different locations in the Atlantic and Pacific Ocean (IPCC, 2013c). Bottom: Trends in concentrations of greenhouse gases. Grey area indicates the 98th and 90th percentiles (light/dark grey) of the recent EMF-22 study (Clarke et al., 2009). Figure from van (van Vuuren et al., 2011).

The steady increase in atmospheric CO₂ concentrations originates from spatially variable emission patterns, and these emissions are projected to depend on socio-economic determinants reflecting human decisions (indirect drivers) regarding greenhouse gas emissions. Figure 4.69 illustrates the CH₄ (methane) emission patterns for 2100 according to the four representative concentration pathway (RCP) scenarios that represent different levels of radiative forcing.

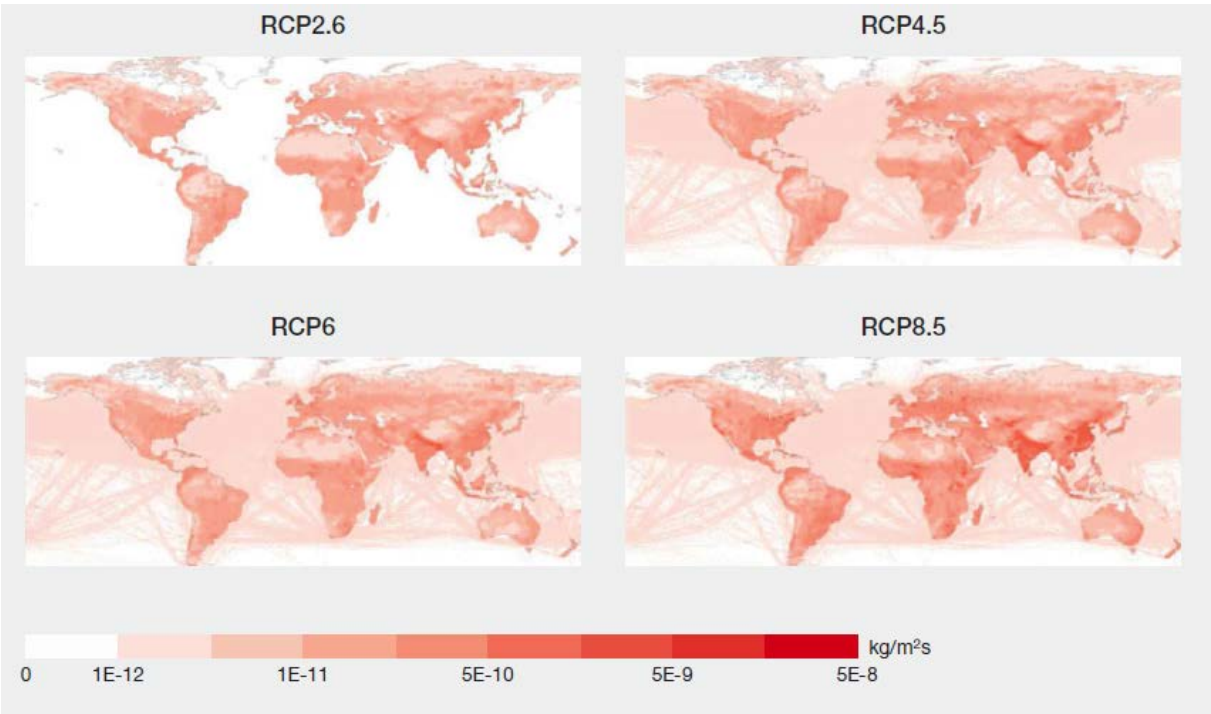


Figure 4.68: Emission pattern for 2100, for CH₄ across the four representative concentration pathways (RCPs). Figure from van Vuuren et al. (2011)

4.7.3 Indirect drivers influencing climate change

Drivers of climate change are the same regardless of whether we are ultimately interested in effects on biodiversity, nature’s contributions to people, or other effects. Drivers of emissions from land-use change have been discussed in Section 4.5. Drivers of greenhouse gas emissions have been assessed in the fifth assessment report of the Intergovernmental Panel on Climate Change (Blanco et al., 2014) and will not be repeated here. However, in contrast to the global level, both primary energy and CO₂ emissions in Europe and Central Asia have been reduced since 1990 (Figure 4.70).

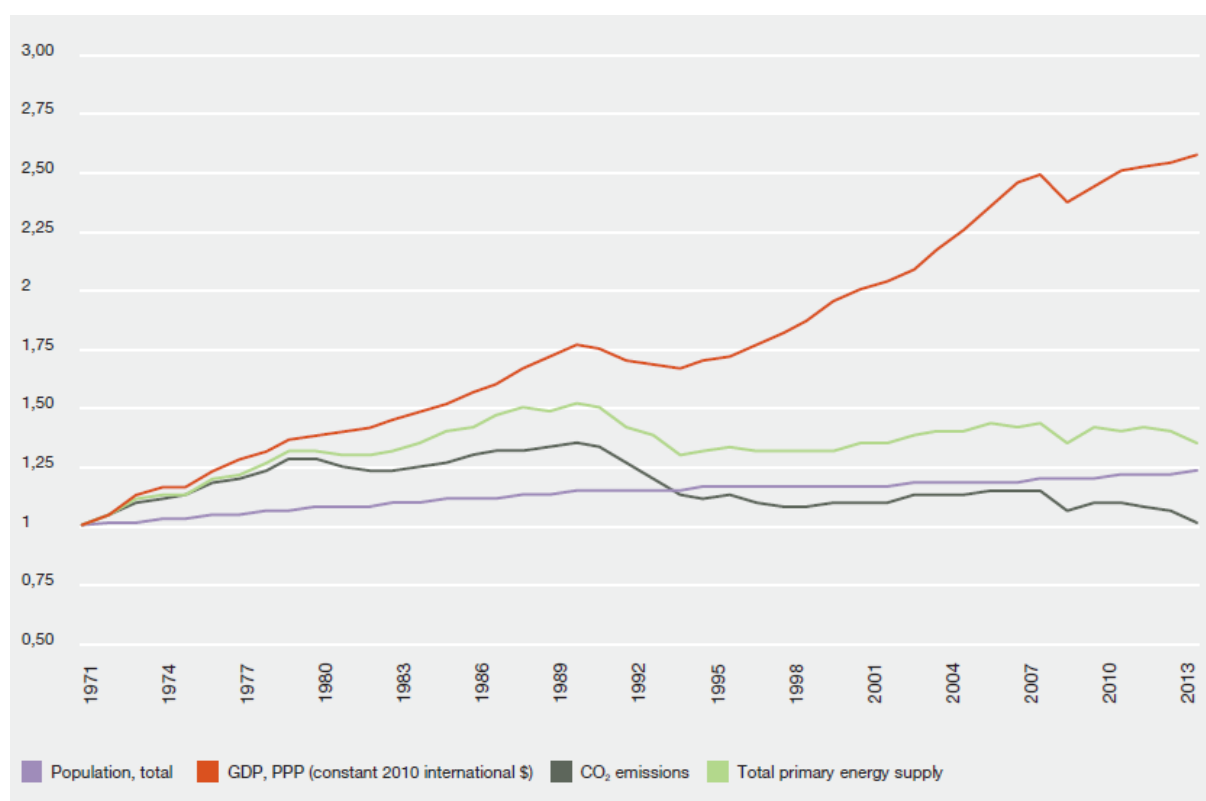


Figure 4.69: Territorial CO₂ emissions in relation to other factors in Europe and Central Asia, 1971-2014 (Own elaboration on OECD (2016)).

To analyse the reasons for this decreasing mission, we use the “Kaya identity” (Kaya, 1990) for territorial CO₂ emissions:

$$\text{CO}_2 \text{ emissions} = \text{population} \times \frac{\text{GDP}}{\text{population}} \times \frac{\text{energy}}{\text{GDP}} \times \frac{\text{CO}_2}{\text{energy}}$$

The two last parts of the Kaya identity, energy intensity of GDP and CO₂ content of energy production, have declined since 1990 in all developed and large developing countries mainly due to technology, changes in economic structure, the mix of energy sources, and changes in the participation of inputs such as capital and labour used (Blanco et al., 2014).

Figure 4.71 shows the relative contribution of each term of the Kaya identity to the annual change in CO₂ emissions in Europe and Central Asia. By comparing the size of the different bars one notices that the growth of GDP per capita (second term of the Kaya identity) is the main driver of CO₂ emission increase, which is well-established (Blanco et al., 2014) and that its effect has for most years only been partially offset by improvements in the energy intensity of GDP (third term) and the CO₂ emissions intensity of energy production (fourth term).

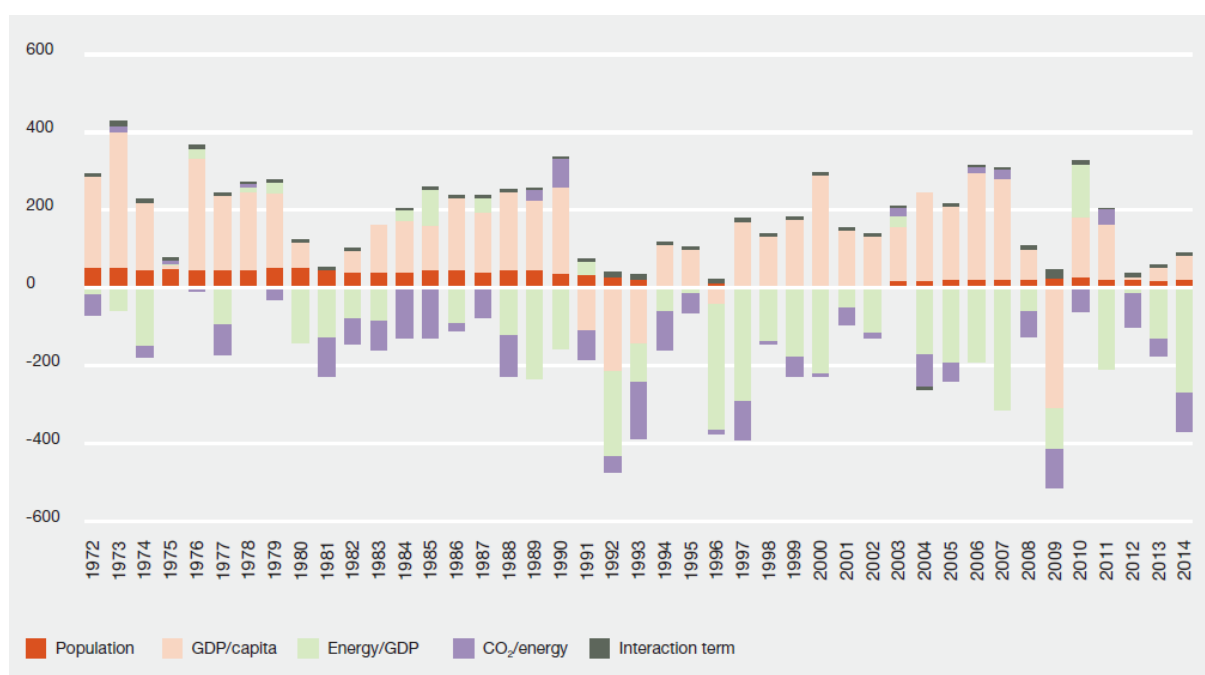


Figure 4.70: Kaya decomposition of CO₂ emissions change in Europe and Central Asia. (Own elaboration on OECD (2016)). “Energy” is total primary energy supply, while “GDP” is taken in PPP values at 2010 international US \$.

The time series in **Figure 4.71** shows two structural breaks, the first after the dissolution of the Soviet Union and the second following the great recession. These years with negative GDP growth (1991-1993 and 2009) were also the years with highest reduction in CO₂ emissions.

As reported in **Table 4.7**, between 1995 and 2008 energy and emissions increased at a lower rate than before 1990, while average GDP continued increasing at more or less the same rate (relative decoupling). In the last four years of available data (2011-2014), there is evidence of small increases in GDP growth, but decreasing paths in both energy and CO₂ emissions (absolute decoupling).

Table 4.7: Rates of change of population, GDP, CO₂ emissions, and energy in Europe and Central Asia. (Own elaboration on OECD (2016)). PPP denotes purchasing power parity.

Rates of growth of	1971-1990	1995-2008	2011-14
Population	0.7%	0.2%	0.4%
GDP, PPP (constant 2010 international US \$)	3.0%	2.9%	1.4%
CO ₂ emissions	1.6%	0.1%	-2.0%
Total primary energy supply	2.2%	0.7%	-1.2%

Two caveats are to be considered. First, the data refer to the aggregation of all countries in Europe and Central Asia. Within this region different patterns are observable and, as noted by the Intergovernmental Panel on Climate Change, the increase of emissions for an additional person varies widely, depending on geographical location, income, lifestyle, and the available energy resources and technologies (Blanco et al., 2014). Second, there is no clear evidence whether (and to what extent) the relative decoupling of CO₂ emissions from GDP growth, indicated by much slower growth of CO₂ partial to GDP as observed from 1995, and the complete decoupling, indicated by a CO₂ decrease at growing

GDP from 2011 are the outcome of interregional flows, e.g. de-industrialization in the region caused by economic growth of countries in other regions. According to some researchers, the relevant decoupling is between prosperity and CO₂ emissions, not GDP growth and CO₂ emissions (T. Jackson, 2009; Raworth, 2017; van den Bergh, 2010).

The drivers of climate change are not limited to the energy and transportation sectors or the Kaya identity. In Section 4.5.1 we assessed intensive agriculture as a carbon source and sequestration by forests as carbon sink. A more comprehensive illustration of major drivers of climate change and their interactions, and impacts on biodiversity, is presented in **Figure 4.72**.

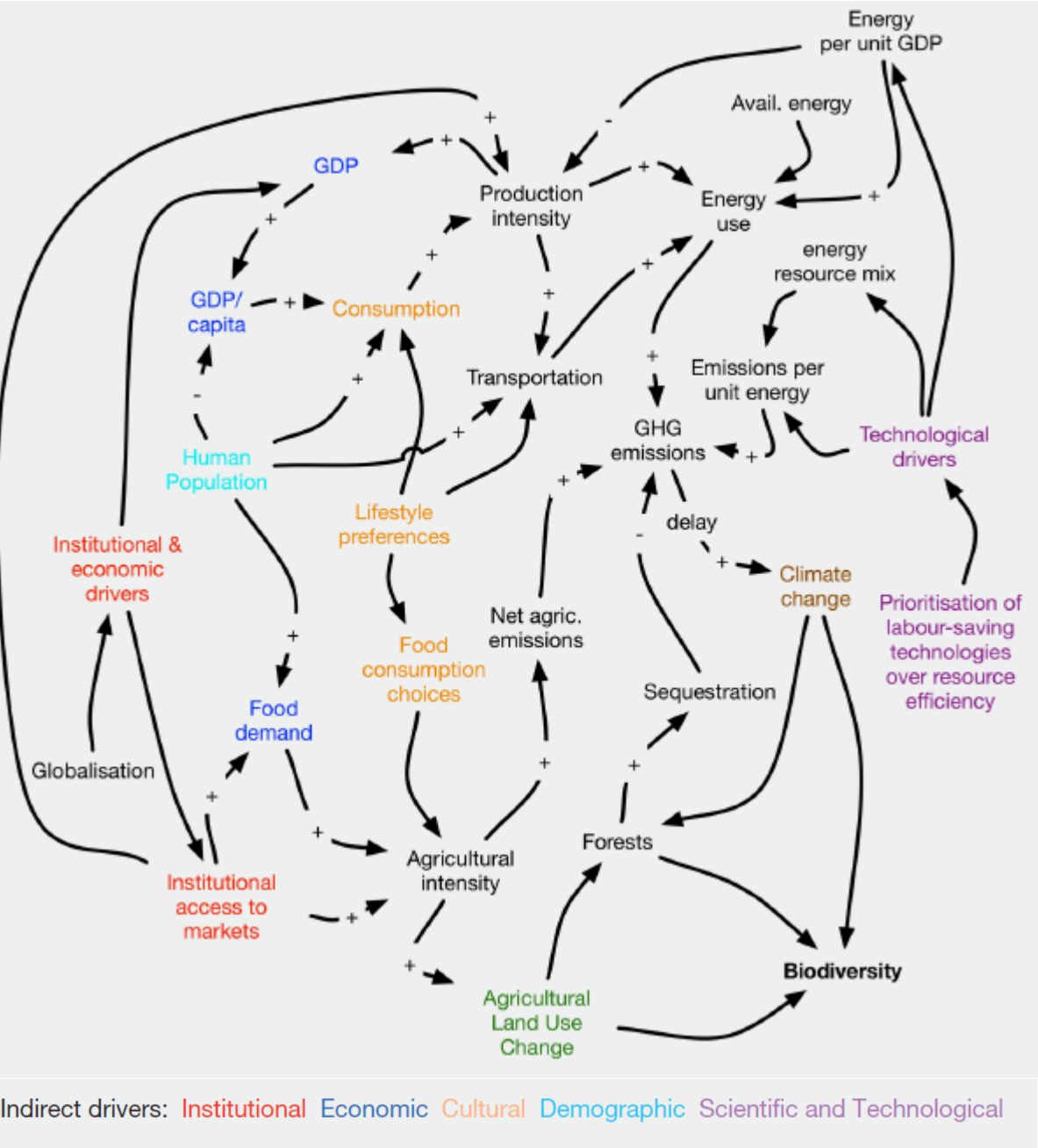


Figure 4.71: Causal loop diagram of drivers of climate change, illustrating the main causes of climate change. See text for further clarification.

4.8 Drivers and effects of invasive alien species

4.8.1 Effects of invasive alien species on biodiversity and nature's contributions to people

Invasive alien species are among the important direct drivers of loss of biodiversity and nature's contributions to people across Europe and Central Asia, especially in combination with other direct drivers (Section 4.9.1) (Anastasopoulou, Chobotova, Dawson, Kluvankova-Oravska, & Rounsevell, 2007; Clavero, Brotons, Pons, & Sol, 2009; Katsanevakis, Wallentinus, Zenetos, Leppäkoski, & Çinar, 2014; MA, 2005b; G. C. Nelson et al., 2005; Sala, 2000). Invasive alien species generally tend to have negative effects on biodiversity (**Fig. 4.73**). However, their magnitude and direction vary both within and between types of impact, across taxa and environments (Bradshaw et al., 2016; IPBES, 2016a; Simon G. Potts et al., 2016; Vilà & Ibáñez, 2011). Negative effects can include displacement and extinction of native species, gene pollution, homogenization of communities, modification of biological interactions, communities, habitats and ecosystem functions, with consequences for human health; and agricultural and economic production (IPBES, 2016a; Katsanevakis et al., 2014; Vilà et al., 2010). Some alien species, and even some invasive alien species, have positive impacts, which include provision of habitat; increasing local species richness and associated ecosystem services, with subsequent economic gains; ecosystem engineering; and aesthetic and cultural value (Goodenough, 2010; IPBES, 2016a; Schlaepfer, Sax, & Olden, 2011). Data limitations across the region, particularly in Central Asia (Dinasilov A., 2013; Khlyap & Warshavsky, 2010; Mamilov, Balabieva, & Koishybaeva, 2010; Reshetnikov, 2010) and for pathogens (H. E. Roy et al., 2017), impede assessment of trends associated with invasive alien species. Priority should be given to improving the evidence-base for impacts of invasive alien species and thereby capacity to inform future assessments (Gurevitch & Padilla, 2004; Jeschke et al., 2014).

Invasive alien species have considerable economic impacts on forestry (H. E. Roy et al., 2014) and agriculture (Paini et al., 2016). Invasive alien insects alone have been estimated to cost US\$2-3.6 billion per year in Western and Central Europe, mostly due to impacts on forestry and agriculture, while invasive alien species can have significant impacts on human health, for example via disease transmission and allergens (Bradshaw et al., 2016; S. Schindler, Staska, Adam, Rabitsch, & Essl, 2015). However, such impacts are considered to be grossly underestimated because of the limited number of studies available within and across Europe and Central Asia (Bradshaw et al., 2016; S. Schindler et al., 2015).

Most invasive alien species present in marine habitats in Europe and Central Asia have been reported to affect more than one species (**Figure 4.73**) (Katsanevakis et al., 2014). Invasive alien species within freshwater environments can cause alterations to the physical, chemical and ecological state eliciting cascading effects that modify biodiversity (Martel et al., 2014), and ecosystem structure and function (Kernan, 2015). Freshwater ecosystems are particularly vulnerable to invasions and the impacts of invasive alien species and so the magnitude of the impact and the consequential ecological transformations are often more severe than in terrestrial ecosystems (R. Francis, 2012; Ricciardi, 2015).

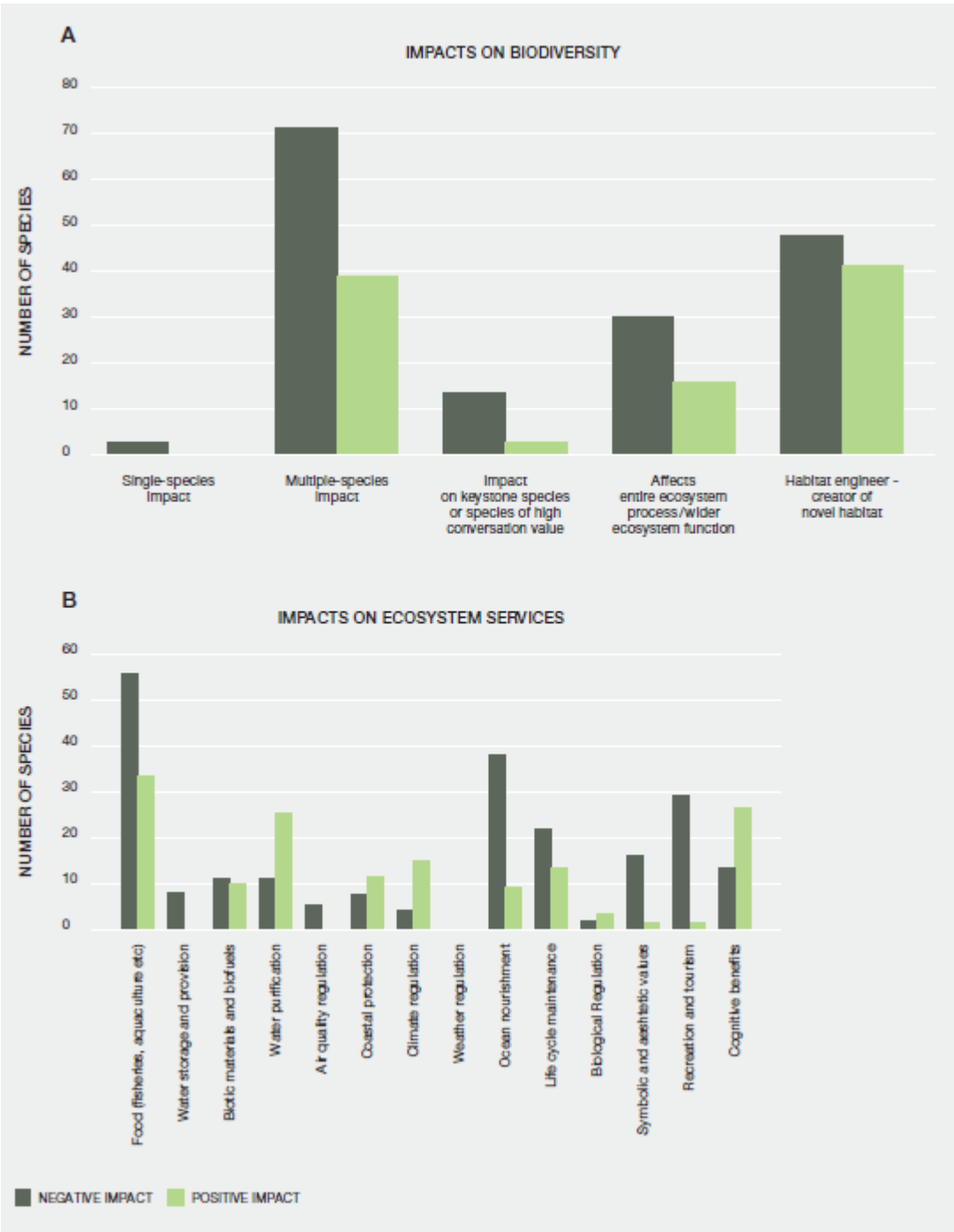


Figure 4.72: Overview of the number of marine alien taxa (out of 110 investigated taxa) that have been reported to affect (A) biodiversity and (B) ecosystem services (nature’s contributions to people) in marine habitats of Europe and Central Asia (Katsanevakis et al., 2014).

4.8.2 Trends in invasive alien species

4.8.2.1 Recent trends

Rates of invasions in Europe and Central Asia have increased markedly since the beginning of the 20th century and the scale and impacts are still increasing, despite increased legal and social responses in recent years (Rabitsch et al., 2016). The number of alien species has increased by 76% between 1970

and 2007 (Butchart et al., 2010). This trend is similar across all environments, taxonomic groups (except mammals), and all subregions of Europe (**Figure 4.74**) (Butchart et al., 2010; DAISIE, 2009; Seebens et al., 2017). Even in remote Arctic and sub-Arctic regions in Europe the number of introduced alien species is substantial (Lembrechts, Milbau, & Nijs, 2014; Ware, Bergstrom, Müller, & Alsos, 2012). In Europe and Central Asia, the highest numbers of reported introductions for most species groups have occurred in Western Europe, but this is expected to increase in Central Europe and Eastern Europe. Data for Central Asia is less comprehensive than for the other subregions; but it is likely that the Central Asia trends are similar to other subregions based on comparable economic developments that are a major driver for invasions (Chytrý et al., 2012; Seebens et al., 2015; Vicente, Alves, Randin, Guisan, & Honrado, 2010).

The number of eradication attempts, and of successful eradications, have been increasing rapidly since the 1990s, but have been mostly confined to Western Europe (DIISE (2015); DAISIE: Database of Island Invasive Species Eradications <http://diise.islandconservation.org/>, 2017). Eradication of invasive alien species tends to be more successful in offshore island habitats and anthropogenic habitats than in (semi-) natural habitats (DIISE, 2015; Pluess et al., 2012).

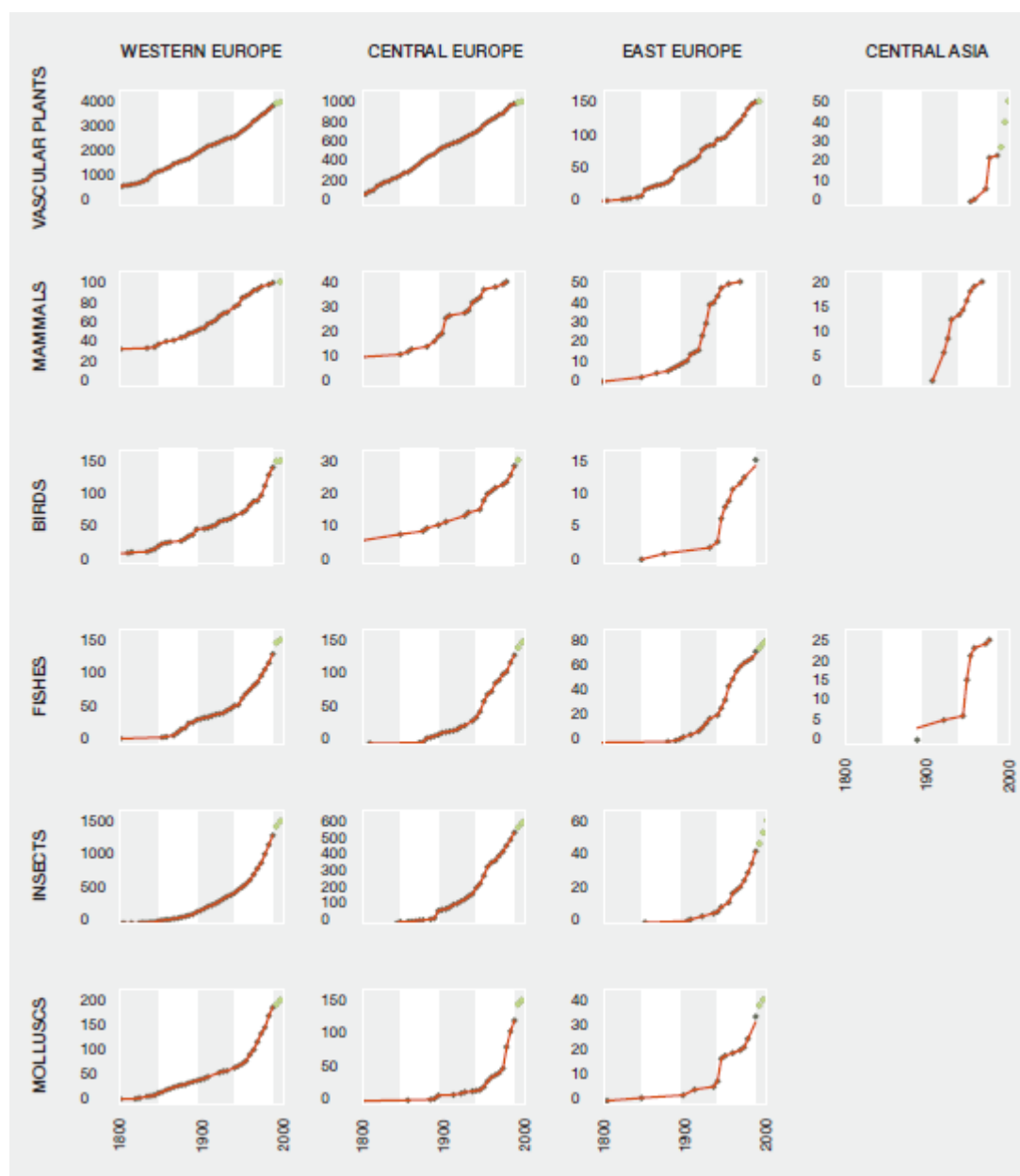


Figure 4.73: Cumulative number of alien species between 1800 and 2000 (dots) for six taxonomic groups in subregions of Europe and Central Asia. The trend is indicated by a running median (red line). Data after 2000 (grey dots) are incomplete and not included in the trend analysis. Adapted from Seebens et al. (2017).

4.8.2.2 Projected future trends

The overall rate of introduction of alien species shows on average no sign of slowing (Chytrý et al., 2012; Seebens et al., 2015) and will most likely remain high or even accelerate due to increasing trade and changing climate (Céline Bellard et al., 2012; Seebens et al., 2017). This high rate is very likely to continue in the short-term, but long-term trends are less clear because they depend on the success of management and policy interventions. Management of invasive alien species is receiving increasing attention but little remains understood about which factors affect the likelihood of successful management (Pluess et al., 2012).

Overall, the invasion threat during the 21st century is expected to be medium to very high in most of the parts of Europe and Central Asia (Early et al., 2016)(**Figure 4.74a**). The exceptions are northern areas of the region, where the threat of invasive alien species is still considered low, although rapidly increasing due to increasing tourism, more human disturbances, and climate warming (Lembrechts et al., 2016, 2014; Pauchard et al., 2016; Ware et al., 2012) (**Figure 4.74b**). The future outcomes of invasions will depend on adoption of effective management and policy measures (Section 4.8.3). For example, plant invasion levels in Western and Central European regions are expected to remain high under “business-as-usual” scenario over the next 60 years (Chytrý et al., 2012). In Eastern and Central European subregions, unprecedented increases in invasive alien species are expected during the 21st century, mostly due to increased transport and indirect effects of socio-economic drivers on other direct drivers (Early et al., 2016). Increasing human population density and increasing national wealth (GDP) are associated with increased risk of alien species introduction and establishment (Chytrý et al., 2008). Lower capacity to apply preventive or mitigation measures, for example in certain Eastern and Central European countries, means that the threats posed by invasive alien species will be greater (Early et al., 2016).

The risk of further invasive alien species establishment is exacerbated because of projected growth in direct (e.g. land-use and climate changes, pollution) and indirect (e.g. trade) drivers facilitating invasions (Celine Bellard et al., 2013; Chytrý et al., 2008, 2012; Early et al., 2016; IPCC, 2014a; Seebens et al., 2015; Vicente et al., 2010)(see **Figure 4.74c**). Some species could increase in abundance in many areas under changing climate conditions, such as grey squirrels that are replacing native red squirrels (Bertolino, di Montezemolo, Preatoni, Wauters, & Martinoli, 2014). Other examples include the caterpillar *Thaumetopoea pityocampa* that is threatening Scots pine in locations that were previously too cold (Toffolo, Bernardinelli, Stergulc, & Battisti, 2006); the overlap between native crayfish and invasive crayfish plague-transmitting species is also projected to increase in Europe (Capinha, Larson, Tricarico, Olden, & Gherardi, 2013). Especially in northern regions, climate warming is expected to affect the number and impact of alien species (Pauchard et al., 2016).

The European Union has recently adopted European Union Regulation 1143/2014 (Section 4.8.3) on invasive alien species. The efficacy of such legislation depends on the commitment of member countries to allocate sufficient resources and ensure adequate enforcement. Furthermore, the ultimate success of regulatory approaches depends on raising public awareness of the threat of invasive alien species leading to changes in lifestyle and consumption preferences (Genovesi, Carboneras, Vilà, & Walton, 2015). In many countries in the region, awareness, expert knowledge,

legislation and allocation for managing threats from invasive alien species is increasing (Early et al., 2016; Turbelin, Malamud, & Francis, 2017) but the efficacy of these measures is yet to be assessed. Overall, the analysed literature suggests that neither Target 5 of the European Union Biodiversity Action Plan nor Aichi Biodiversity Target 9 (“protected areas increased and improved”) of the Strategic Plan for Biodiversity 2011-2020, will be met for Europe and Central Asia.

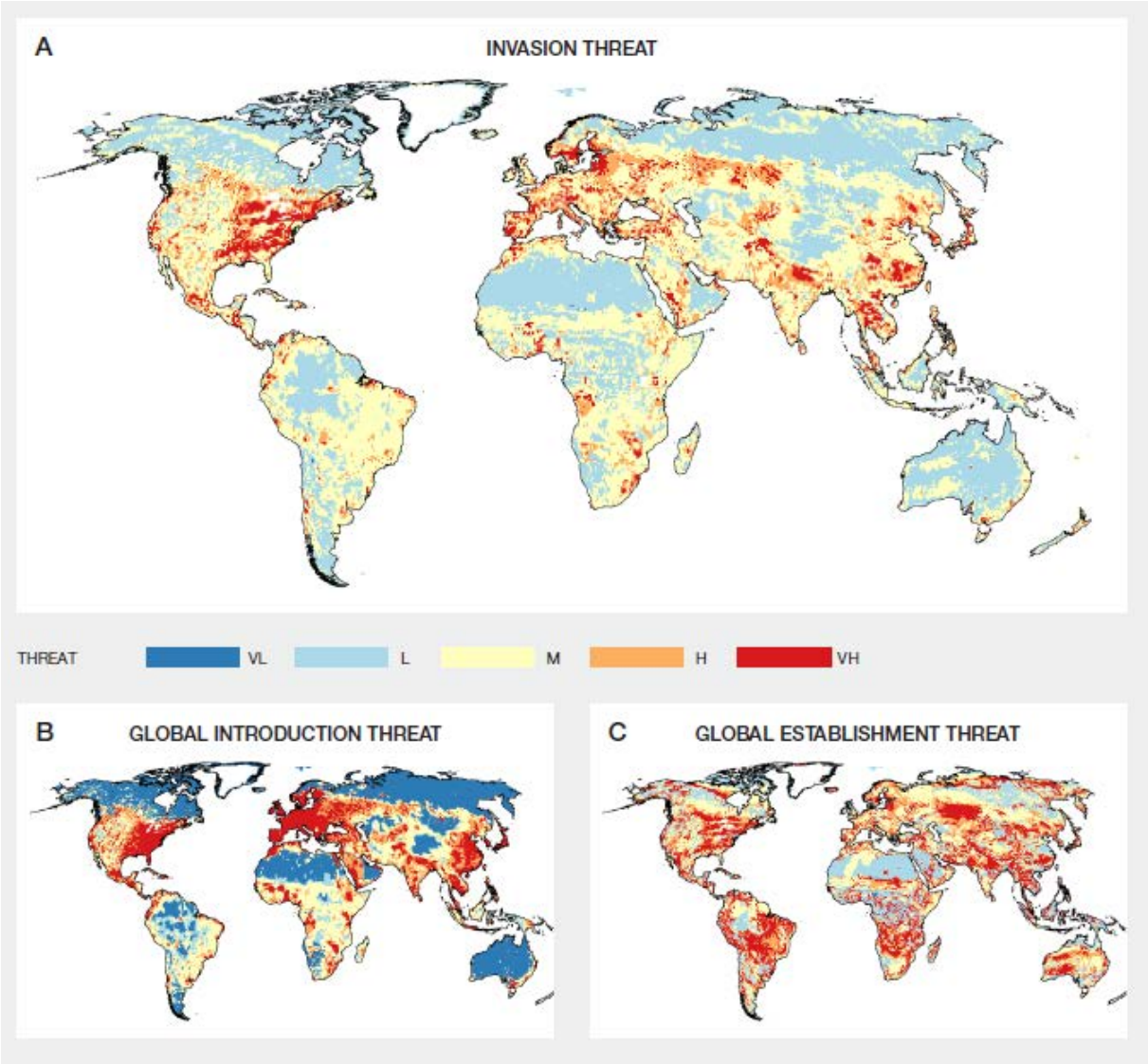


Figure 4.74: Global invasion threat for the 21st century (modified from Early et al. (2016)). Airport and seaport capacity, as well as animal, plant and total imports between 2000 and 2009, was combined into global introduction risk. Projected biome shifts and increase in agricultural intensity and fire frequency between 2000 and 2100 (emissions scenario A2) were combined into global establishment threat. Introduction and establishment axes were combined into overall invasion threat. (a) invasion threat, (b) introduction threat, (c) establishment threat All maps are displayed using the colour scheme from a, which runs from very high (VH; red) to very low (VL; blue). The scale was determined by ranking the threat value in each map grid cell, and binning cells into the following percentiles: 100–90% = very high; 90–80% = high; 80–50% = medium; 50–20% = low; and 20–0% = very low.

4.8.3 Indirect drivers influencing invasive alien species

The invasion process (i.e. transportation, introduction, establishment and spread) is strongly influenced by economic factors including trade and tourism (see **Figure 4.76**) (Essl et al., 2011; Pyšek et al., 2010; Seebens et al., 2017; Turbelin et al., 2017). Economic activities, either intentional or non-intentional, are the foremost influence on introduction pathways of alien species (see **Figure 4.77**). Most economic drivers have increased in Europe and Central Asia, and they can be associated with an increase in numbers of invasive alien species (Katsanevakis, Zenetos, Belchior, & Cardoso, 2013; Turbelin et al., 2017; Zieritz et al., 2017). Economic development, especially in emerging economies, will drive future invasions as tourism, trade (including the pet and aquaria trade) and infrastructure projects accelerate the introduction of invasive alien species via the escape, contaminant, stowaway and corridor pathways (Hulme, 2015)(see **Figure 4.80** and **Figure 4.81**).

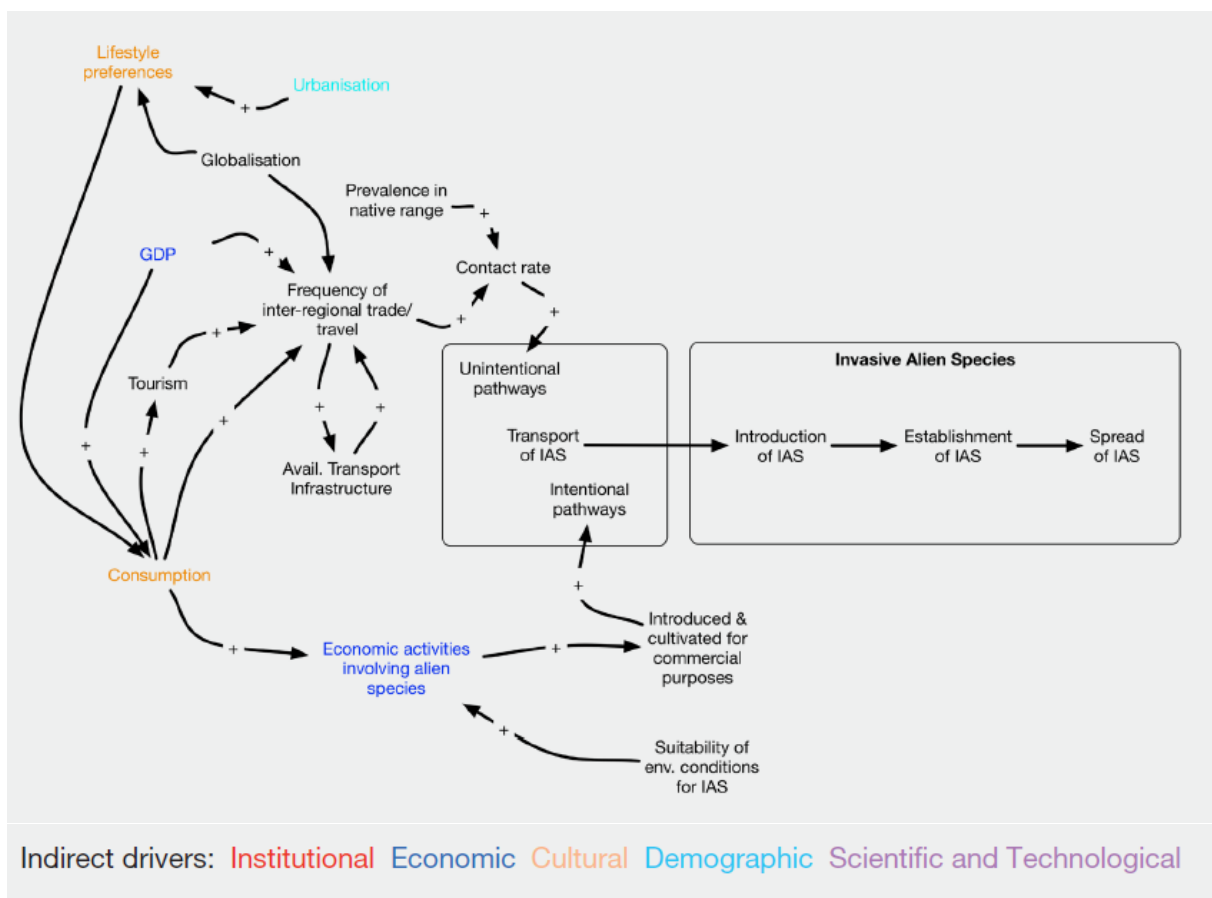


Figure 4.75: Causal loop diagram of drivers of invasion by alien species. The invasion process includes both intentional and unintentional introduction pathways. Interlinked economic, socio-cultural, and demographic drivers account for most introduction of alien species.

The main pathway for intentional (and to some extent un-intentional) introductions of invasive alien species in all taxonomic groups in Europe and Central Asia is trade of horticultural and ornamental plants (Turbelin et al., 2017; Zieritz et al., 2017). Invasion pathways related to tourism are also likely to increase in importance over the next few decades. Tourists introduce alien species, including potential invasive alien species with a high survivorship, on their clothing, footwear and equipment, for example via transportation of soil containing living organisms (bacteria, fungi, seeds, nematodes, arthropods: McNeill et al., 2011). A greater frequency of contact between tourists and potential invasive alien species is likely because current high levels of international tourist movements are expected to grow

up to 2030 and there is increased tourist preference for recreation (e.g. golf, fishing), agrotourism, remote places (e.g., mountains, Arctic), national parks (Hulme, 2015; Pauchard et al., 2016).

The establishment and spread of invasive alien species is ultimately influenced by the suitability of environmental conditions (see **Figure 4.76**) in recipient biomes, or the ability of the invading species to adapt to these conditions or otherwise to self-create suitable conditions. Environmental suitability is a dynamic quality of biomes, subject to influence by climate change, and a key economic factor in determining species viability for import and cultivation (e.g. horticultural and silvicultural trade) and thus represents an important component of establishment processes (Chapman, Purse, Roy, & Bullock, 2017; Early et al., 2016). In addition to environmental suitability, the spread of established invasive alien species is also a factor of the susceptibility of native habitats and populations to further invasion. This susceptibility is influenced by a number of direct drivers of change including climate change, adverse land-use change, genetic pollution, and changes in natural disturbance regimes, which are, in turn, typically directly or indirectly driven by economic development and socio-economic trends (Early et al., 2016).

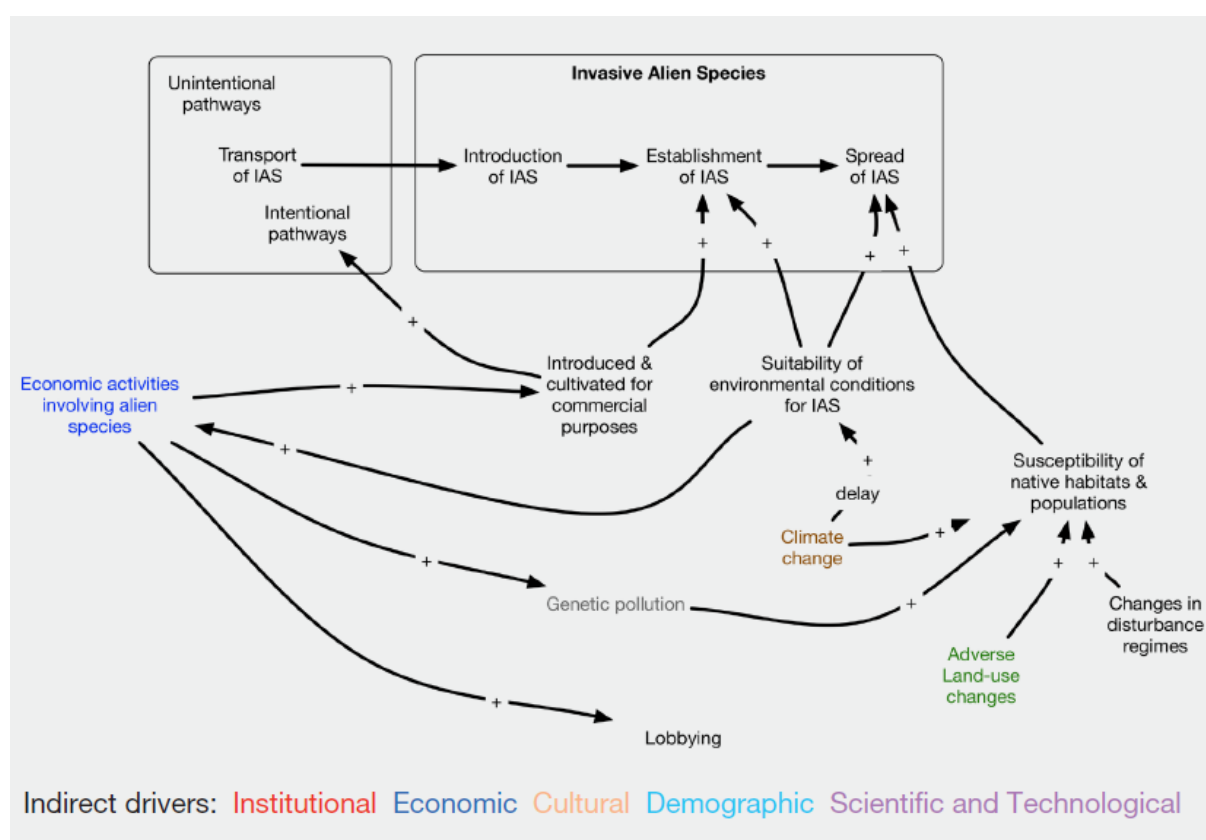


Figure 4.76. Causal loop diagram of the drivers of establishment and spread of invasive alien species. The suitability of environmental conditions has a strong influence on both the economic viability of intentionally introduced species as well as the establishment and spreading of invasive species. A number of indirect drivers including climate change and land-use change also influence the suitability of environmental conditions and the susceptibility of native habitats and populations to invasion.

Diverse impacts of invasive alien species and high eradication costs of already established invasive alien species have necessitated the adoption of legal instruments (see **Figure 4.78**). Countries with greater numbers of recorded invasive alien species have adopted more targeted international treaties (**Figure 4.79a**) and national and subnational regulations and legislation (see **Figure 4.79b**) specifically dealing with invasive alien species (Turbelin et al., 2017). Western European countries have greater

numbers of recorded invasive alien species due to trade and colonial histories (Turbelin et al., 2017) and better scientific knowledge of species invasion status and native biodiversity (Lambdon et al., 2008). Consequently, Western European countries have adopted numerous legal instruments targeting alien species; Central European and Eastern European countries have fewer legal instruments, and countries in Central Asia have the fewest legal instruments (**Figure 4.79**). Within the European Union, the regulation on invasive alien species implemented in 2014 includes three types of interventions: prevention, early detection and rapid eradication, and management ("EU Regulation 1143/2014 on Invasive Alien Species," 2014). Globally, the number of international agreements relevant to control of invasive alien species as well as the number of countries that are party to these agreements has consistently increased since the 1950s (McGeoch et al., 2010).

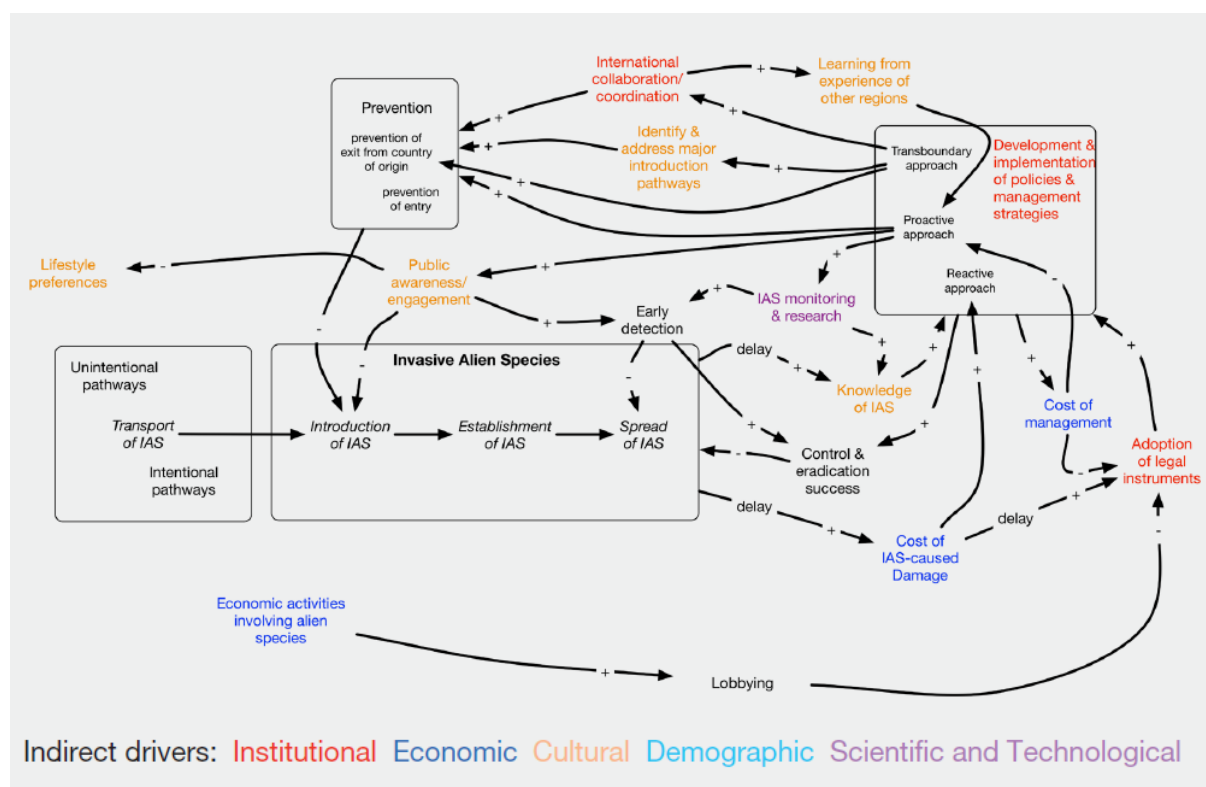


Figure 4.77. Causal loop diagram illustrating costs from and resulting policies due to invasive alien species. Impacts and costs resulting from increased abundance of invasive alien species has driven the adoption of legal instruments in Europe and Central Asia. Most policies are reactive in nature, focusing on control and eradication measures once species have become established.

Information on legal instruments concerning invasive alien species is largely missing from Central Asia, either because of a lack of data or a genuine lack of policy. In the latter case, the development of legislation and regulations in this subregion could (1) prevent the introduction of invasive alien species or (2) help reduce the spread and impact of existing ones. Species introductions as well as spread and impact of existing invasive alien species are likely to be exacerbated (Turbelin et al., 2017) based on trends of other indirect drivers, especially socio-economic drivers such as development of the oil industry and its related infrastructure in Kazakhstan, Turkmenistan and Uzbekistan (Dimeyeva, 2013). From available information, mainly based on eports by the Convention on Biological Diversity, countries in Central Asia currently have little capacity to respond to threats by invasive alien species and impending or future introductions, establishment or spread (Early et al., 2016).

The majority of legal instruments are reactive, targeting introduction and spread of invasive alien species upon arrival within national borders. Very little attention has been given to preventing the

arrival of invasive alien species, except for species that have known public health impacts (Turbelin et al., 2017). Comprehensive border controls to prevent introduction of potential invasive alien species are adopted by very few countries in Europe and Central Asia (Early et al., 2016). Current regulations lack a transboundary perspective and insufficiently cover major introduction pathways (Hulme, 2015). For example, most efforts in regulation of transport-related non-intentional introductions of invasive alien species have addressed the role of shipping, while tourism, another major route of stowaway alien species, remains largely neglected (Hulme, 2015).

A general recommendation from studies on invasive alien species regulation and management is to develop educational outreach programs to raise awareness of the general public and industry (Hulme, 2015; Katsanevakis et al., 2013; Turbelin et al., 2017; Zieritz et al., 2017). Increased public awareness could lead to changes in preferences for alien species as pets or other ornamental purposes, increased vigilance by tourists and the tourist industry, and improved early detection of alien species.

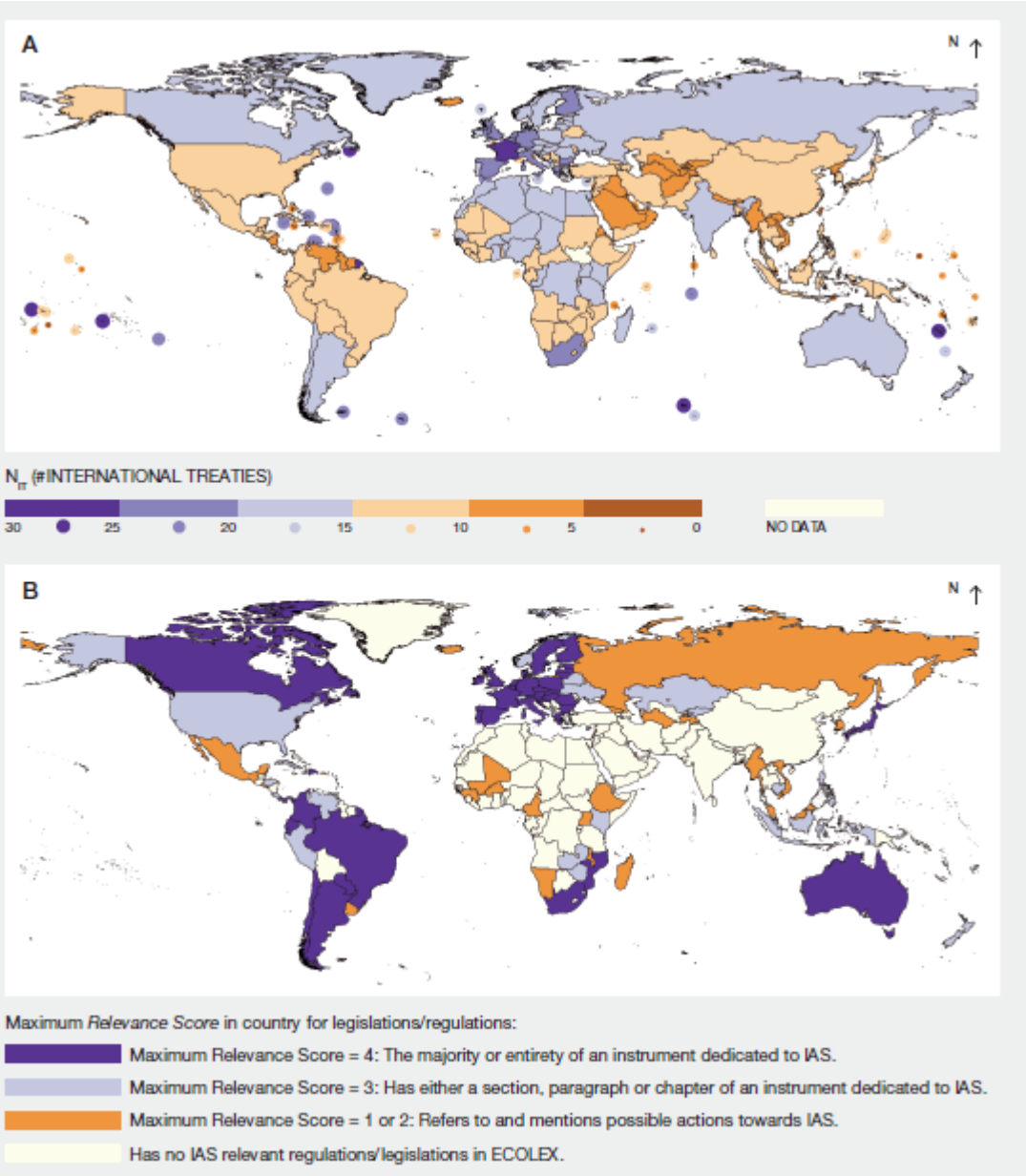
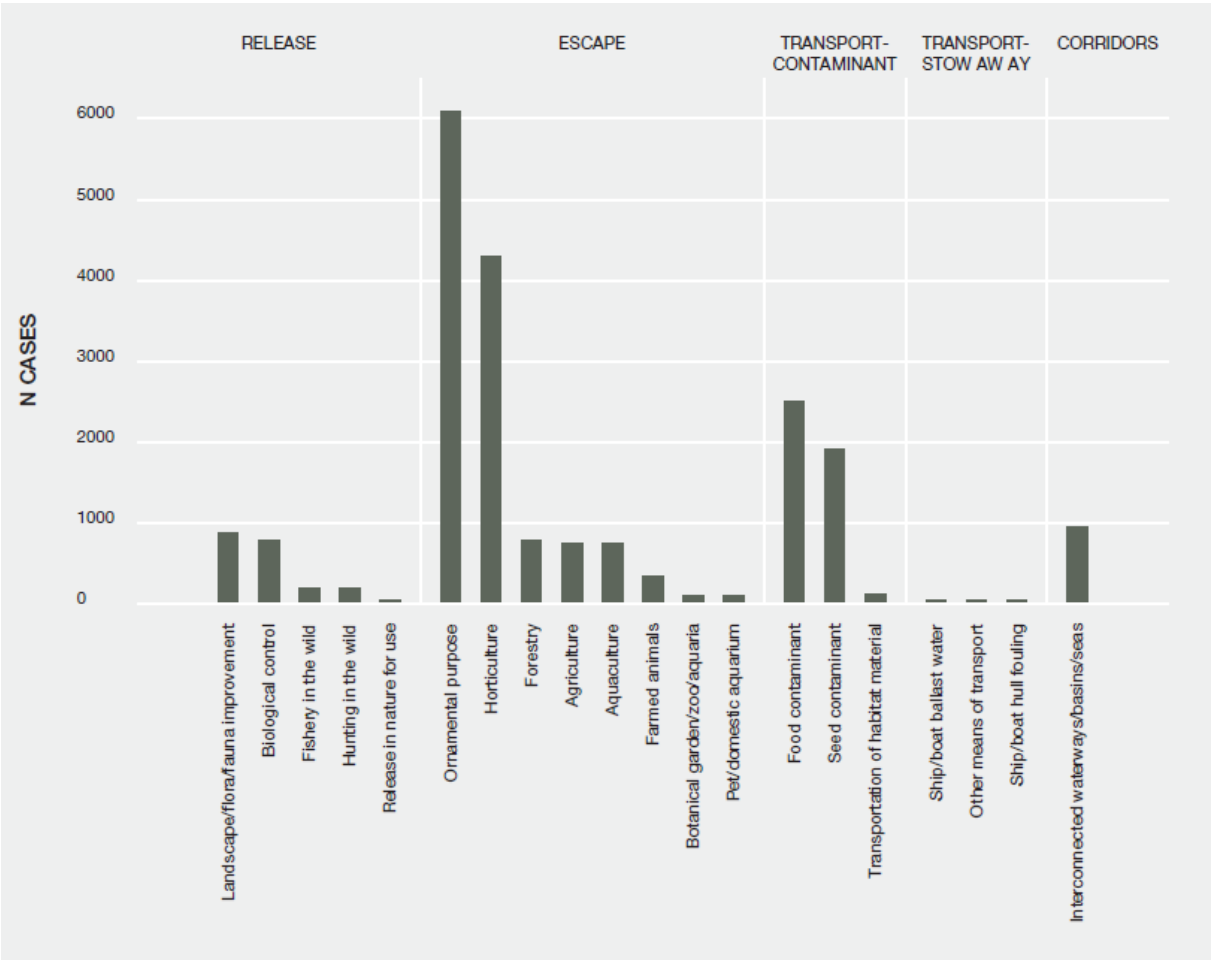


Figure 4.78: Global map of legal instruments (1933 - 2015) relevant to invasive alien species. Shown are (a) number of international treaties mentioning invasive alien species to which each country is signatory, including global and regional treaties for 1933 - 2015) and (b) map of the maximum

21546 relevance score for each country that has national or sub-national regulations of legislation in place,
21547 relevant to invasive alien species (1980 - 2015). Overseas territories have been allocated the same
21548 number of international treaties as their sovereign state (from Turbelin et al., 2017).



21549
21550 **Figure 4.79: Frequencies of introduction pathways of known cases of introduction of over 14,000**
21551 **invasive alien species profiled in the Delivering Alien Invasive Species Inventories for Europe**
21552 **(DAISIE); level 2 categories. Source: CBD (2014), Pathways of introduction of invasive species, their**
21553 **prioritization and management.**

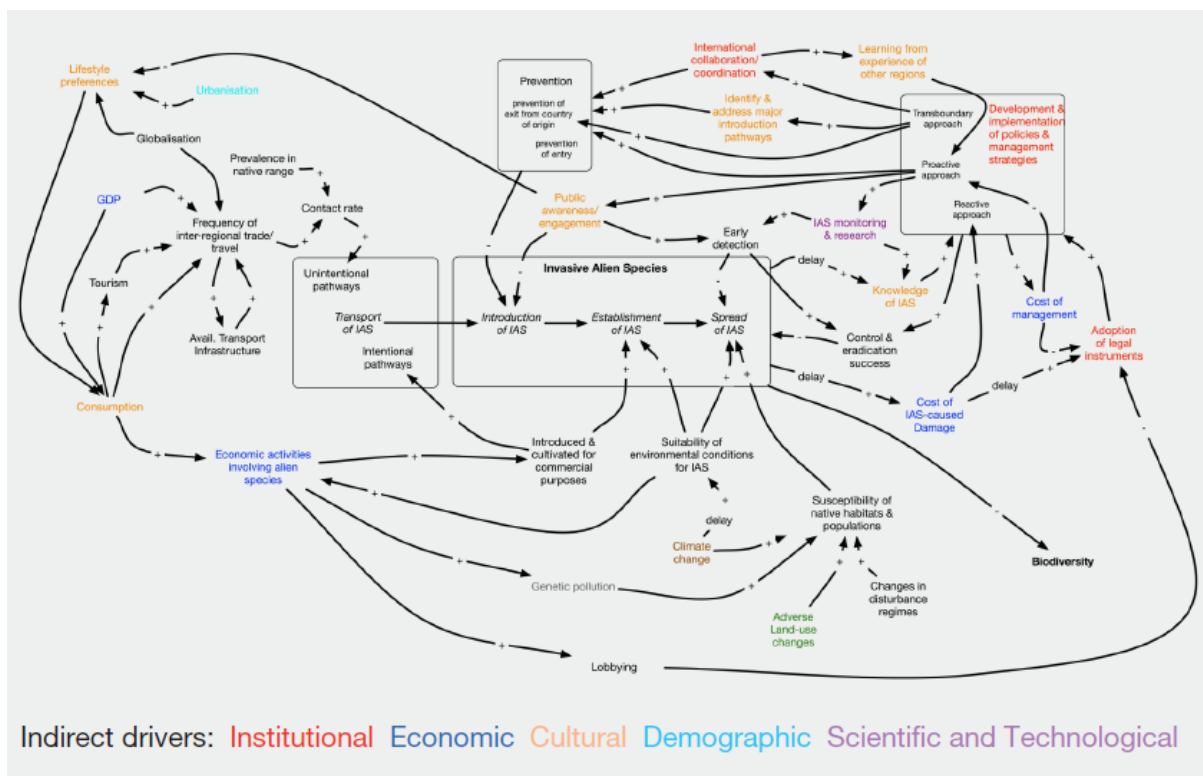


Figure 4.80: Causal loop diagram of drivers of feedback mechanisms between effects of invasive alien species and direct and indirect drivers. Feedbacks are largely limited to rarely implemented policies aimed at raising public awareness. Most current policy responses are reactive, directed towards control of existing invasive alien species populations, and do not address underlying drivers.

4.9 Synthesis of direct driver trends and impacts in Europe and Central Asia

4.9.1 Interaction among direct drivers and time-lagged effects on biodiversity and nature's contributions to people

Drivers, both direct and indirect, rarely act in isolation. In essence, a change in biodiversity and nature's contributions to people is almost always an outcome of several interacting drivers. While it may be possible to determine which drivers are involved, it is not always easy to assess or even quantify the respective contribution of the individual drivers in affecting biodiversity, including ecosystems. In addition, positive feedbacks can influence driver dynamics and amplify their combined effects. For example, land-use change and destruction of habitats can influence climate change (locally) due to the changes in land surface albedo and evapotranspiration (Kalnay & Cai, 2003).

Drivers do not act in isolation with interactions between them affecting driver trends and thus also the effects on biodiversity and nature's contributions to people. In **Box 4.7**, we exemplify the interaction of indirect and direct drivers using three examples of invasive alien species. They illustrate how different drivers – partly indirect and partly direct – jointly affect the driver “invasive alien species”. Many other examples of driver interactions exist in the ecological literature. For example, the interplay of climate change, pollution and invasive alien species exacerbates the negative impact of land-use change and management intensity (Collier, Probert, & Jeffries, 2016; Haddad et al., 2015; IPBES, 2016a; Kalnay & Cai, 2003; Mantyka-Pringle et al., 2012; Segan, Murray, & Watson, 2016; Vilà & Ibáñez, 2011). Small and isolated populations of organisms are less well buffered against climate change (McInerny, Travis, & Dytham, 2007), are more susceptible to invasion (Didham, Tylianakis, Gemmell, Rand, & Ewers, 2007; Haddad et al., 2015) and can be more exposed to pollution (Weathers, Cadenasso, & Pickett, 2001). Declining area of habitats and their increasing isolation also reduces the possibilities for the compensatory migration of species in response to changing climate (Bocedi, Zurell, Reineking, & Travis, 2014; Meier, Lischke, Schmatz, & Zimmermann, 2012; Adam J Vanbergen & The Insect Pollinators Initiative, 2013). Furthermore, a modelling study has shown that impact assessments focused on one sector (agriculture, forestry, water use, etc.) alone without considering interactions between these sectors will likely lead to over- or under-estimation of the projected impacts, as direct and indirect drivers affect each other mutually (Harrison, Dunford, Holman, & Rounsevell, 2016).

Individual and combined effects of different direct drivers can have chronic, prolonged and delayed consequences on biodiversity and nature's contributions to people, due to considerable time lags that many species and ecological systems have in response to changes in their environment (Dullinger et al., 2012; Ewers & Didham, 2006; Halley, Monokrousos, Mazaris, Newmark, & Vokou, 2016; Ilkka Hanski & Ovaskainen, 2002; Helm et al., 2006; Kuussaari et al., 2009; David Tilman et al., 1994; Urban, 2015). Even if habitat conditions no longer meet the minimum requirements for species persistence (e.g. too small habitat area, too isolated habitats, climatic conditions becoming unsuitable), actual extinctions can take time, creating an extinction debt in many contemporary habitats or ecosystems (Ilkka Hanski & Ovaskainen, 2002; Kuussaari et al., 2009). Time-lags also characterize species colonizations of new habitats, termed “colonization credit” or “immigration deficit”. Delayed immigration characterizes both non-native species invasions as well as natural, climate-driven or land use-driven migrations and colonizations of native species (S. T. Jackson & Sax, 2010). By masking the full extent of impacts of direct and indirect drivers on biodiversity and nature's contributions to people, time-delays in species dynamics pose considerable challenges for research and conservation. Extinction debt can last decades or even centuries and, if left unnoticed, can lead to serious overestimation of current biodiversity status and underestimation of the impact of combined and direct effects of direct drivers on biodiversity and nature's contributions to people (Kuussaari et al.,

2009). For example, taking extinction debt into account increased projected extinctions threefold from 5% to 15% under currently projected climate change scenarios (Urban, 2015). On the other hand, when recognized in good time, extinction debt and colonization credit can provide opportunity to avoid some of the projected extinctions or undesired colonizations via active and knowledgeable conservation and restoration activities (Halley et al., 2016; Török & Helm, 2017).

Box 4.7: Interaction of direct and indirect drivers in their effects on biodiversity and nature's contributions to people

Economic and demographic drivers are both highly correlated with invasion of alien species

The number of invasive alien species is strictly correlated with economy and with human population. In particular, the level of wealth, defined as cumulative economic prosperity, has been shown to have a strong influence on the cumulative level of invasions (Pyšek et al., 2010); this correlation has a temporal effect, and the number of invasive alien species reflects historic rather than contemporary economy (Essl et al., 2011).

Climate change, habitat fragmentation and fish invasion

Connectivity is extremely important for freshwater fish migration, and natural and man-made barriers can consequently seriously facilitate or hamper fish dispersal. This has, for instance, been illustrated for pike (*Esox lucius*) in Sweden, where they are currently absent from isolated lakes and lakes upstream from channel slopes steeper than c. 7% (Catherine L. Hein, Öhlund, & Englund, 2011; Spens, Englund, & Lundqvist, 2007). At the same time, pike are top predators, able to extirpate cold-adapted salmonid species under warmer conditions in small lakes, whereas those species co-exist under colder conditions and in larger lakes (C. L. Hein, Öhlund, & Englund, 2013). Due to human-mediated introductions and climate warming pike are now spreading upstream and to more northern latitudes, while at the same time climate warming improves pike performance, often resulting in local extinctions of cold-adapted specialist fish species (C. L. Hein et al., 2013). The strong effect of climate change on these predator fish (both influencing their spread and their competitiveness) provides managers with a difficult challenge regarding the restoration of natural connectivity to improve the free movement of species. Whereas on the one hand connectivity is important to native species that need to track climate change, barriers such as waterfalls, dams and weirs can limit the upstream spread of problematic or very competitive species, thereby creating refuges and protection for threatened species. This example illustrates how climate change may alter the effect of connectivity restoration on fish biodiversity. It also illustrates trade-offs in biodiversity conservation.

Economic and demographic drivers, climate and land-use change, and invasive alien species

Distribution patterns of invasive alien species have been shown to be strongly linked to climate, land use, human demography and socio-economic activities (C. Bellard, Genovesi, & Jeschke, 2016; Celine Bellard et al., 2013; Gallardo & Aldridge, 2013; Gallardo et al., 2015; Pyšek et al., 2010). Specifically, in Europe and Central Asia, invasive alien species patterns are mostly driven by socio-economic activities (see Section 4.8.3). Climate acts as a broad-scale limiting factor to invasive alien species distributions, whereas land use (also driven by socio-economic activities) affects invasive alien species patterns at the global, regional and local scales (Celine Bellard et al., 2013). Consequently, changes in these drivers alter patterns in invasive alien species distribution and impact (Diez et al., 2012; Dukes & Mooney, 1999; Hellmann, Byers, Bierwagen, & Dukes, 2008; Meyerson & Mooney, 2007; Walther et al., 2009). Climate change (temperature and precipitation changes, CO₂ concentrations, extreme events) has been hypothesized to enhance biological invasions (Celine Bellard et al., 2013; Diez et al., 2012; Dukes & Mooney, 1999; Hellmann et al., 2008). Land-use change is expected to alter invasive alien species patterns depending on habitat types and uses, with the most intensely used and disturbed habitats being the most prone to invasions (Chytrý et al., 2012). Increasing socio-economic activities are expected to increase invasions by increasing propagule pressure, introduction pathways and habitat disturbances (C. Bellard et al., 2016; Essl et al., 2011; Gallardo & Aldridge, 2013; Gallardo et al., 2015; Pyšek et al., 2010). Projected future patterns in plant invasions in relation to land-use change show strongest increases for the northern parts of Western Europe (all scenarios), and strongest decreases in the southern parts of Western Europe in scenarios of abandonment of agricultural land (Chytrý et al., 2012). Future projections in distribution patterns of 100 of the world's worst invasive alien species in relation to both climate and land-use change project important

21655 increases in northern parts of Western Europe, slight increases in Central Asia and western parts of Eastern
21656 Europe, but decreases around the Mediterranean basin (Celine Bellard et al., 2013).

21657 **End of Box 4.7**

21658

21659 4.9.2 Synthesis of direct driver trends and impacts

21660 In this section, we summarize assessed trends and impacts of direct drivers. **Figure 4.82** and **Figure**
21661 **4.83** illustrate the direction of driver trends and their inferred impact in the different subregions and
21662 units of analysis. An increasing trend (upward-pointing arrow) means that the direct driver shows an
21663 increasing trend, while downward pointing arrows indicate a decreasing trend. Impacts on biodiversity
21664 associated with the direct driver trends are indicated by colours, with red and green indicating negative
21665 and positive impacts. An increasing driver trend can have a positive impact on overall biodiversity in
21666 an area or unit of analysis. However, we assessed to what degree the trend affects the biodiversity
21667 typical for the unit of analysis in that area not simply biodiversity as a whole. For example, climate
21668 change can be expected to increase the overall biodiversity in an area, yet it will negatively affect the
21669 biodiversity of a given spatial unit, e.g. of temperate forests, if these are converted into other units of
21670 analysis, e.g. Mediterranean forests, over time. Hence, overall biodiversity might be higher in
21671 Mediterranean forests, but species associated with temperate forests would be lost.

21672 In some cases, trends do not have a clear direction in a subregion and unit of analysis, but rather show
21673 both decreasing and increasing trends or impacts. We therefore also allowed trends and impacts to be
21674 of “variable” nature. The confidence in the statements on driver trends and impacts is indicated by
21675 the thickness of symbols or by the saturation of the colours. The notion of “irrelevant” was assigned
21676 to combinations of drivers, subregions and units of analysis that do not exist. For example, there are
21677 no “deep marine waters” or “Mediterranean forests” in Central Asia.

21678

21679 4.9.2.1 Recent trends in direct drivers and their impact

21680 The recent trends in direct drivers and their associated impact on biodiversity and nature’s benefits to
21681 people are summarized across Europe and Central Asia and major units of analysis within the study
21682 region (see **Figure 4.82**). Land-use change, pollution and partly natural resources extraction showed
21683 the strongest increase, and had the clearest negative impacts in many units of analysis or subregions.
21684 Invasive alien species have steadily increased as a driver of biodiversity alteration and loss, and already
21685 showed strong negative impacts in some (wetland types, cultivated areas and inland freshwaters),
21686 while in other systems the impact is less severe or still mostly lacking (e.g. cold grasslands). Climate
21687 change has also steadily increased as a driver, yet its impact on biodiversity is still marginal and
21688 confined to relatively few units of analysis (mostly urban and water systems).

21689 Confidence is generally high in all statements, yet often somewhat decreasing towards Eastern Europe
21690 and Central Asia, usually due to a lack of accessible literature and insufficient number of studies
21691 analysing trends and impacts. The availability of repeated reports on climate change trends and
21692 impacts (e.g. IPCC, 2013b, 2014a, 2014b) results in an overall very high level of confidence in all
21693 statements on trends and impacts throughout the study region. Lowest confidence levels were found
21694 for trends and impacts for the driver natural resources extraction. This driver is usually more limited
21695 in its spatial extent, and thus more difficult to quantify across larger regions, both for trends and
21696 impacts.

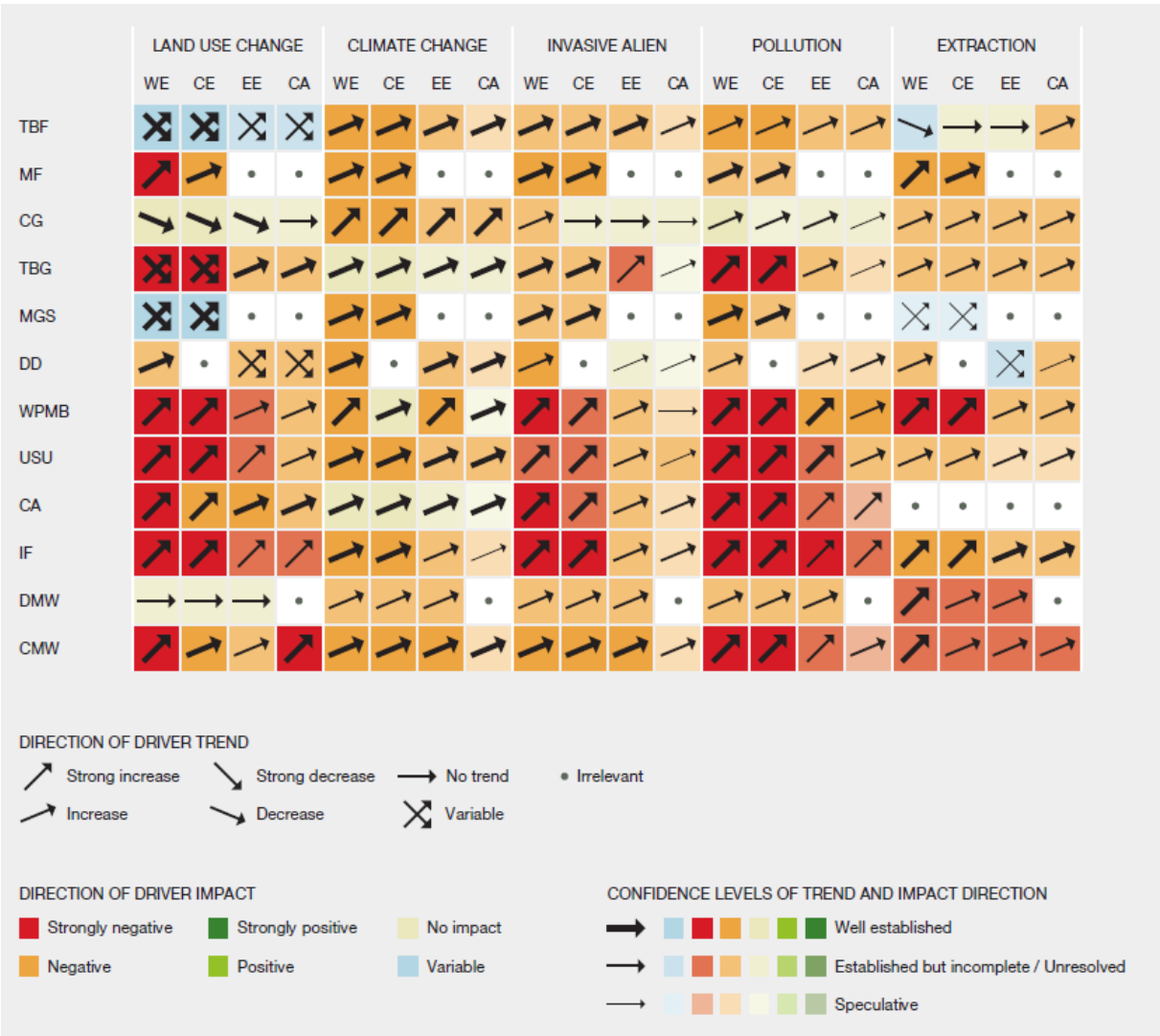
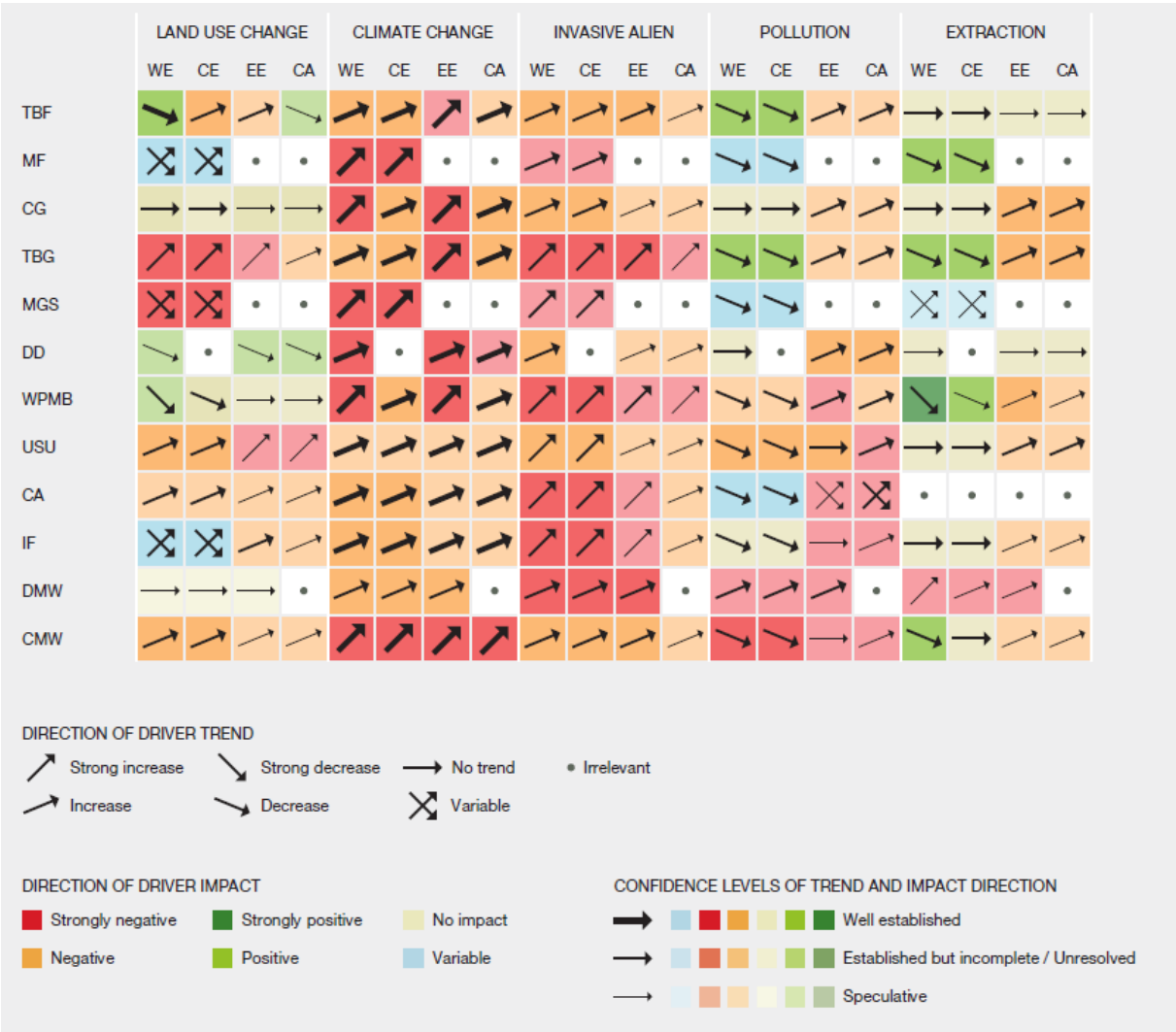


Figure 4.81: Combination of recent trends in direct drivers and impacts of driver trends on biodiversity and nature’s benefits to people. “Increase” stands for accelerating trends in direct drivers, while “decrease” stands for decelerating driver trends. Positive (green) and negative (red) impacts on biodiversity indicate the effects of the associated driver trends. Confidence levels are indicated by the thickness of arrows and saturation of colours. Units of analysis are: TBF: temperate and boreal forests; MF: Mediterranean forests; CG: cold grasslands; TBG: temperate and boreal grasslands; MGS: Mediterranean grasslands and scrubs; DD: drylands and deserts; WPMB: wetlands, peatlands, mires & bogs; USU: urban & semi-urban systems; CA: cultivated areas; IF: inland freshwaters; DMW: deep marine waters; CMW: coastal marine waters.

4.9.2.2 Projected future trends in direct drivers and their impact

The projected future trends in direct drivers and their associated impact on biodiversity and nature’s contributions to people are summarized across Europe and Central Asia and major units of analysis within the study region (Figure 4.83). Land-use change, pollution and partly natural resource extraction showed strongest projected decreases, and had overall some reduction in its impacts on biodiversity in several units of analysis or subregions. On the contrary, climate change and invasive alien species will become the most important threats to biodiversity compared to the other three drivers. The reduction of driver effects on biodiversity is stronger in Western and Central Europe than in Eastern

21716 Europe and Central Asia for land-use change, pollution and natural resources extraction. On the other
21717 hand, invasive alien species are still projected to be a bigger threat to units of analysis in Western and
21718 Central Europe than in Eastern Europe and Central Asia, reflecting the importance of traffic and
21719 economic growth for the trends in invasive alien species.



21720
21721 **Figure 4.82: Combination of projected future trends in direct drivers and impacts of projected driver**
21722 **trends on biodiversity and nature’s benefits to people. See Figure 4.81 for more information on**
21723 **symbols, colours and abbreviations of units of analysis.**

21724 Confidence is generally lower for projected future (compared to recent) trends and impacts in all
21725 statements, and often even lower towards Eastern Europe and Central Asia. The exception to this rule
21726 is the confidence in trends of climate change, for which a wealth of information is available (e.g. IPCC,
21727 2013b, 2014a, 2014b). For some systems only marginal information is available in the Europe and
21728 Central Asia region. Again, lowest confidence levels are available for trends and impacts in the driver
21729 natural resources extraction.

21730
21731 **4.9.3 Synthesis of indirect drivers**

21732 Sections 4.4-4.8 presented Causal Loop Diagrams (CLDs) to illustrate the dynamic inter-relationships
21733 within and between indirect and direct drivers of change in biodiversity and nature’s contributions to

21734 people. Our findings show that the general combination of indirect drivers that underpin trends in
21735 direct drivers is often similar across Europe and Central Asia. At the same time, causal relationships
21736 between individual indirect drivers and their effects on direct drivers are context specific.

21737 Indirect drivers are often triggered by processes in different sectors of society and by the activities of
21738 diverse groups of actors and stakeholders. Their cumulative effects provoke dynamics of indirect
21739 drivers and as a consequence a specific impact on a direct driver. For example, intensification of
21740 conventional agriculture in Europe and Central Asia is influenced by cultural, institutional, economic,
21741 technological and demographic drivers. Whilst the consolidation of farms has led to some
21742 improvements in economic viability, it is also linked to the erosion of local traditions and of a sense of
21743 long-term stewardship and responsibility for the land, which are important for sustaining management
21744 practices for biodiversity.

21745 The CLDs were also used to illustrate complex adaptive systems in terms of how the effects on
21746 biodiversity and nature's contributions to people feed back to the indirect drivers. Knowledge and
21747 awareness, filtered by beliefs and values, are often the primary cultural-religious drivers in this
21748 feedback. Environmental NGOs have had an important role in increasing awareness of forest
21749 biodiversity, while scientific organizations have been important for issues such as fishing and climate
21750 change. Public awareness has not always been necessary, e.g. in the case of invasive alien species, new
21751 regulations have been passed in response to scientific knowledge with less political pressure. There
21752 are also differences between subregions. For example, for agriculture, the Common Agricultural Policy
21753 in the European Union includes institutional and agri-environmental support (payments), which has a
21754 positive (green) effect on biodiversity (**Figure 4.84**). However, these payments only reduce the effects
21755 of global trade and competition, so the economic drivers work in both ways (grey colour in **Fig. 4.84**).
21756 Cultural change increases demand for organic food in Western Europe. Technological drivers in the
21757 resource extraction sectors generally increase degradation, while "end-of-pipe" technologies have
21758 successfully reduced pollution (**Figure 4.84**).



Figure 4.83: The colour shows the impact of an indirect driver on a direct driver's effect on biodiversity and nature's contributions to people along a gradient from negative to positive effects. The colour intensity from high to low indicates a level of confidence from *established* to *unresolved*.

Institutional drivers have often been used to soften the effects that economic profit-seeking drivers have on technological change and a range of direct drivers. Regulations have reduced some pollution, e.g. acidification and toxicity from heavy metals. Other direct drivers, e.g. pesticides and ammonia pollution from agriculture, have been regulated although not sufficiently to reverse negative trends.

Economic drivers have not changed very much as a result of knowledge and awareness of ecosystem degradation and have generally a negative effect on biodiversity and nature's contributions to people (**Figure 4.83**). Environmental and ecological fiscal reforms have not generally been implemented: environmental taxes have not increased since 2002. On top of this, harmful subsidies to fishing and mining provide market actors with strong incentives to continue externalising environmental costs. Hence, economic drivers still support intensive agriculture and forestry as well as unsustainable natural resource extraction, especially fishing and mining. When economic drivers have been employed to halt biodiversity loss, e.g. through agri-environmental schemes and carbon taxes or trading schemes, this has generally been insufficient to halt habitat fragmentation and degradation or climate change. As long as a good quality of life is associated with GDP growth, the perceived trade-off between a good quality of life and sustainable ecosystem management and governance will continue to be a major obstacle, if sustainable development is to be achieved.

4.10 References

Note: Cyrillic references sorted in at the end of the reference list.

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5 Chapter 5: Current and Future Interactions between Nature and Society

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25298 **Executive Summary**

25299 **Priorities for future sustainable development within Europe and Central Asia are formulated in**
 25300 **visions by governments and societal actors. Integrated scenario and modelling studies enable the**
 25301 **assessment of impacts on nature, nature's contributions to people, and a good quality of life**
 25302 **resulting from these priorities, and help to co-design and co-deliver appropriate pathways to**
 25303 **sustainable futures (*established but incomplete*) (5.1.2, 5.4.2, 5.4.3, 5.5.2).** Priorities for future
 25304 sustainable development are captured in regional visions, which describe a future desired by society
 25305 or parts of society in Europe and Central Asia. Matching these priorities to the Sustainable
 25306 Development Goals and Aichi Biodiversity Targets revealed that regional priorities include sustainable
 25307 economic growth in tandem with sustainable industrialization (Goal 8, Goal 9), sustainable agriculture,
 25308 forestry, aquaculture and management of natural resources (Goal 15, Target 7), all promoted by
 25309 sustainable consumption and production patterns (Goal 12, Target 4). Climate action and sustainable
 25310 energy (Goal 13, Goal 7) are also priorities. Reduced inequalities (Goal 10), gender equality (Goal 5)
 25311 and peace, justice and strong institutions (Goal 16), as well as representation of a diverse range of
 25312 values, are less emphasized (*established but incomplete*) (5.1.2, 5.4.2, 5.4.3).

25313 Integrated assessments of future interactions between the priorities for sustainable development and
 25314 nature and its contributions to people, which support proactive decision-making that anticipates
 25315 change, mitigates undesirable trade-offs and fosters societal transformation in pursuit of a good
 25316 quality of life, are rare due to the complexity of human and environment interdependencies (*well*
 25317 *established*) (5.1.1, 5.3.1, 5.5.3, 5.5.4). Nevertheless, ignoring these complexities is likely to cause
 25318 undesired trade-offs and to prevent the realization of synergies (5.3.1). Cross-sectoral and cross-scale
 25319 integration of adaptation, mitigation and transformative actions and policies by multiple actors is key
 25320 to the co-design and co-delivery of appropriate pathways to realize visions of future sustainable
 25321 development (*established but incomplete*) (5.4.2, 5.4.3, 5.5.2, 5.5.3, 5.5.5, 5.5.6).

25322 **The choices made by decision-makers and societal actors are expected to lead to large differences**
 25323 **in future impacts on nature, nature's contributions to people, and good quality of life within Europe**
 25324 **and Central Asia (*established but incomplete*) (5.2.3, 5.3.3, 5.3.4).** More positive impacts are
 25325 **projected under futures that assume proactive decision-making on environmental issues and**
 25326 **promote a more holistic approach to managing human and environmental systems which supports**
 25327 **multifunctionality and multiple contributions from nature to people (*established but incomplete*)**
 25328 **(5.2.3, 5.3.3, 5.3.4).** Projecting historical trends into the future under a *business-as-usual* scenario
 25329 results in stable trends in nature (e.g. reflected in biodiversity vulnerability indices), negative trends in
 25330 nature's regulating contributions (e.g. regulation of climate or hazards and extreme events) and mixed
 25331 trends in nature's material contributions (e.g. food production) (*established but incomplete*) (5.3.3,
 25332 5.6.1).

25333 Different assumptions about future trends in drivers lead to widely varying projected impacts on
 25334 nature, nature's contributions to people and a good quality of life. Under *economic optimism*
 25335 scenarios, where global developments are steered by economic growth and environmental problems
 25336 are only dealt with when solutions are of economic interest, an increase in the provision of most of
 25337 nature's material contributions to people (e.g. food and timber) is projected associated with a general
 25338 decline in nature and its regulating contributions to people (e.g. air and water quality regulation)
 25339 (*established but incomplete*) (5.3.3, 5.6.1). Under *regional competition* scenarios there is a growing gap
 25340 between rich and poor, increasing problems with crime, violence and terrorism, and strong trade
 25341 barriers. Consequently, its impacts are highly mixed with generally large declines in nature (e.g. habitat
 25342 maintenance and creation) and the most negative impacts of all scenarios on nature's non-material
 25343 contributions to people (e.g. learning and inspiration) and good quality of life indicators (e.g. health

25344 and wellbeing) (*established but incomplete*) (5.3.3, 5.6.1). *Inequality* scenarios, which assume
 25345 increasing economic, political and social inequalities, where power becomes concentrated in a
 25346 relatively small political and business elite who invest in green technology, result in negative impacts
 25347 on nature's regulating contributions to people (*established but incomplete*), but mixed or unclear
 25348 impacts on other indicators (*inconclusive*) (5.3.3, 5.6.1).

25349 Under *global sustainable development* scenarios, which are characterized by an increasingly proactive
 25350 attitude of global policymakers towards environmental issues and a high level of regulation, positive
 25351 impacts are projected for nature and its regulating contributions to people. Predominantly positive
 25352 trends are also projected for nature's material contributions to people and good quality of life
 25353 indicators, with some regional variation (*established but incomplete*) (5.3.3, 5.6.1). Under *regional*
 25354 *sustainability* scenarios, which show increased concern for environmental and social sustainability and
 25355 a shift toward local and regional decision-making, similar impacts are projected as for *global*
 25356 *sustainable development*. *Regional sustainability*, however, leads to slightly fewer benefits for nature's
 25357 regulating and material contributions to people (with decreases in food provision) than *global*
 25358 *sustainable development* and more positive impacts on nature's non-material contributions to people
 25359 and good quality of life, particularly traditional knowledge and supporting identities reflecting the local
 25360 focus of the *regional sustainability* scenario (*established but incomplete*) (5.3.3, 5.6.1).

25361 **Trade-offs between nature and different contributions from nature to people are projected under**
 25362 **all plausible futures for Europe and Central Asia (*established but incomplete*) (5.3.3, 5.3.4). How**
 25363 **these trade-offs are resolved depends on political and societal value judgements within each**
 25364 **plausible future. In general, those futures where environmental issues are mainstreamed across**
 25365 **sectors are more successful in mitigating undesirable cross-sector trade-offs, resulting in positive**
 25366 **impacts across a broad range of indicators concerning nature, nature's contributions to people and**
 25367 **good quality of life indicators (*established but incomplete*) (5.3.3, 5.6.1).** Trade-offs between nature's
 25368 material and regulating contributions to people are commonly projected in the *economic optimism*
 25369 and *regional competition* scenarios, which tend to promote a limited number of nature's material
 25370 contributions to people. For example, increases in food provision (generally associated with the
 25371 expansion of agricultural land or the intensification of livestock production and fish captures) are often
 25372 associated with decreases in the provision of nature's regulating contributions to people (e.g.
 25373 prevention of soil erosion, regulation of water quality and quantity) and nature values. Similar trade-
 25374 offs were projected between increases in timber provision and decreases in nature's regulating (e.g.
 25375 carbon sequestration) and non-material (e.g. aesthetic value) contributions to people. Such trade-offs
 25376 lead to strong positive effects in nature's contributions to people with market values and negative
 25377 effects in nature's contributions to people without market values (*established but incomplete*) (5.3.3,
 25378 5.6.1).

25379 Trade-offs were also apparent under the sustainability scenario archetypes, particularly in relation to
 25380 the use of land and water (e.g. effects of agricultural extensification – the opposite of agricultural
 25381 intensification - or increases in bioenergy croplands on other land uses and biodiversity) (*established*
 25382 *but incomplete*) (5.6.1). However, such scenarios proactively deal with such trade-offs through, for
 25383 example, political choices aiming to maximize synergies through mainstreaming and
 25384 multifunctionality (*global sustainable development*) or through societal choices to live less resource-
 25385 intensive lifestyles and, hence, reduce demand for nature's material contributions to people (*regional*
 25386 *sustainability*).

25387 **Impacts of plausible futures differ across the regions of Europe and Central Asia. Hence, regional and**
 25388 **national decision-makers face various trade-offs between nature and its various contributions to**
 25389 **people. Cooperation between countries opens up possibilities to mitigate undesirable cross-scale**

25390 **impacts and to capitalize on opportunities (*established but incomplete*) (5.3.3).** In Central Asia,
 25391 significant water shortages are projected in the long-term. This affects farmers' choices between
 25392 intensive crop production and more sustainable production with resulting impacts on nature's
 25393 regulating contributions to people, such as water quality (*established but incomplete*) (5.3.3). Similar
 25394 impacts on water stress are projected under future scenarios for Central Europe, including decreases
 25395 in multiple contributions from nature to people from wetlands (*established but incomplete*) (5.3.3).
 25396 Transboundary and integrated water management strategies that protect minimum water levels for
 25397 the environment are projected to mitigate these negative impacts. In Eastern Europe, particularly
 25398 Russia, trade-offs between wood extraction and carbon sequestration are projected. Sustainable
 25399 forest management and reforestation of areas set aside from agricultural activities are suggested as
 25400 having the potential to mitigate such trade-offs. Similarly, in mountain systems in Central and Western
 25401 Europe and in marine systems in all subregions adaptive management strategies are projected to
 25402 address the vulnerability of the majority of nature's contributions to people (*established but*
 25403 *incomplete*) (5.3.3).

25404 In the European Union (EU), significant differences between northern and southern countries are
 25405 projected. Most scenarios indicate increases in agricultural production for food, feed and bioenergy
 25406 for northern European Union countries, while decreases in agricultural and timber production, as well
 25407 as increases in water stress, are projected for southern European Union countries. The latter is
 25408 projected to have considerable negative impacts on nature's non-material contributions to people,
 25409 such as national heritage and tourism-related services dependent on local food production. Scenarios
 25410 which included international coordination of adaptive measures across geographical areas were
 25411 projected to have better capacity to cope with, or mitigate, undesirable cross-scale impacts
 25412 (*established but incomplete*) (5.3.3).

25413 **Future impacts of drivers of change on nature and its contributions to people in Europe and Central**
 25414 **Asia are likely to be underestimated because scenario studies are dominated by a few individual**
 25415 **drivers (e.g. climate change) and often omit other important drivers (e.g. pollution) that may**
 25416 **adversely affect their impacts (*well established*) (5.2.2, 5.3.2).** Scenario studies predominantly focus
 25417 **on single direct drivers and fail to capture interactions between drivers (*well established*) (5.2.2,**
 25418 **5.3.2).** Climate change is the most represented single direct driver in scenarios of biodiversity and
 25419 ecosystem change. By contrast other direct drivers, such as pollution and invasive alien species, which
 25420 are known to have an adverse impact on nature and its contributions to people, are poorly represented
 25421 in scenario studies (*well established*) (5.2.2). Single-driver scenarios fail to capture various dynamics
 25422 such as feedbacks and synergies between and amongst indirect and direct drivers operating at
 25423 different scales. Policy approaches that consider single drivers or single sectors are unlikely to
 25424 successfully address environmental problems as they do not consider trade-offs between different
 25425 drivers, impacts and responses. Integrated, multi-driver scenario studies offer a more realistic
 25426 assessment of impacts to inform robust decision-making about future sustainable development
 25427 pathways that avoid unintended consequences (*established but incomplete*) (5.2.1, 5.2.2, 5.2.4, 5.3.1,
 25428 5.3.3, 5.3.4, 5.4.4, 5.4.5, 5.5.5).

25429 **Priorities for future sustainable development expressed by governments and other societal actors**
 25430 **for Europe and Central Asia are more widely achieved under plausible futures that consider a diverse**
 25431 **range of values (*established but incomplete*) (5.3.4, 5.5.4, 5.5.5, 5.6.1).** Recognizing the different time
 25432 frame of the scenarios of plausible futures (often 2050 or later) to those stated in the Sustainable
 25433 Development Goals and Aichi Biodiversity Targets (2030 or 2020), continuing current trends under a
 25434 *business-as-usual* scenario is estimated to lead to failure in achieving most of the Sustainable
 25435 Development Goals (13 out of 17), but mixed effects on achieving the Aichi Biodiversity Targets (8
 25436 achieved). *Economic optimism* is estimated to have a mixed level of success in achieving the goals (8

25437 achieved), but would fail to achieve the majority of the targets (16 out of 20), while *regional*
 25438 *competition* fails to reach the majority of all goals and targets (15 and 19, respectively). The focus of
 25439 these scenarios on instrumental values and individualistic perspectives, with little acknowledgement
 25440 of relational or intrinsic values, means they are unlikely to offer effective sustainable solutions to
 25441 environmental and social challenges (*established but incomplete*) (5.3.4, 5.6.1).

25442 In contrast, the *sustainability* scenarios (*regional sustainability* and *global sustainable development*)
 25443 are estimated to achieve the majority of the Sustainable Development Goals and Aichi Biodiversity
 25444 Targets. Such scenarios attempt to support nature and its multiple nature's contributions to people
 25445 and aspects of a good quality of life. Thus, they represent a greater diversity of values, but often at the
 25446 acceptance of lower, or more extensive, production of nature's material contributions to people
 25447 (*established but incomplete*) (5.3.4, 5.6.1).

25448 **Multiple alternative pathways exist to achieve the priorities for future sustainable development set**
 25449 **by governments and societal actors within Europe and Central Asia and in particular for mitigating**
 25450 **trade-offs between nature and nature's contributions to people (*established but incomplete*) (5.5.2).**
 25451 **The most promising pathways include long-term societal transformation through continuous**
 25452 **education, knowledge sharing and participatory decision-making. Such pathways emphasize**
 25453 **nature's regulating contributions to people and the importance of relational values in facilitating a**
 25454 **holistic and systematic consideration of nature and nature's contribution to people across sectors**
 25455 **and scales (*established but incomplete*) {5.5.3, 5.5.4}.** Four types of pathways have been developed
 25456 to address trade-offs between food, water, energy, climate and biodiversity at different scales (5.5.2).
 25457 *Green economy* pathways focus on sustainable intensification and diversification of production
 25458 activities coupled with the protection and restoration of nature. *Low carbon transformation* pathways
 25459 focus on biofuel production, reforestation and forest management. Both types of pathways include
 25460 actions related to *technological innovation, land sparing or land sharing*. *Green economy* and *low*
 25461 *carbon transformation* pathways do not fully mitigate trade-offs between nature's material
 25462 contributions to people, nature conservation, and nature's regulating and non-material contributions
 25463 to people (*established but incomplete*) (5.5.2, 5.5.4).

25464 *Ecotopian solutions* pathways focus on radical social innovation to achieve local food and energy self-
 25465 sufficiency and the production of multiple contributions from nature to people. They include actions
 25466 on multifunctionality within individual land uses with connecting green infrastructure, urban design
 25467 and food production (*established but incomplete*) (5.5.2, 5.5.4). *Transition Movements* pathways
 25468 emphasize a change towards relational values, promoting resource-sparing lifestyles, continuous
 25469 education, new urban spatial structures and innovative forms of agriculture where different
 25470 knowledge systems are combined with technological innovation. Transformation is achieved through
 25471 local empowerment, participatory decision-making processes, community actions and voluntary
 25472 agreements. As opposed to other pathways, *transition movements* pathways address all of the
 25473 Sustainable Development Goals identified as being important in the Europe and Central Asia visions
 25474 (5.1.2, 5.5.4), except Goal 7 (sustainable energy). The narrative offers the broadest set of actions
 25475 targeting elements of nature, multiple contributions from nature to people (material, regulating and
 25476 non-material) and multiple dimensions of a good quality of life (*established but incomplete*) (5.5.2,
 25477 5.5.4, 5.6.1).

25478 **Different sets of actions and combinations of policy instruments are suggested by the different**
 25479 **pathways. Joint instruments suggested across pathways give priority to participation, education and**
 25480 **awareness raising, and often cross-scale integration and mainstreaming of environmental objectives**
 25481 **across sectors (*established but incomplete*) (5.5.2, 5.5.3, 5.5.4, 5.5.6).** The *green economy* and *low*
 25482 *carbon transformation* pathways build towards sustainability without challenging the economic

25483 growth paradigm. They are implemented through combinations of top-down legal and regulatory
 25484 instruments mixed with economic and financial instruments designed at regional (European Union) or
 25485 national levels (Eastern Europe and Central Asia). Such pathways are often formulated at a sectoral
 25486 level, and integration across sectoral pathways is critical. However, because *green economy* and *low*
 25487 *carbon transformation* pathways do not fully mitigate trade-offs, they may not be sufficient alone to
 25488 achieve sustainability (*established but incomplete*) (5.5.2, 5.5.4, 5.6.1).

25489 The trade-offs are better addressed by diverse local bottom-up *transition movements* or *ecotopian*
 25490 *solutions* pathways (5.5.2). Such pathways reconsider fundamental values and lifestyles through sets
 25491 of actions focusing on less resource-intensive lifestyles, education, knowledge sharing, good social
 25492 relations and equity (e.g. food and dietary patterns, transport, energy and consumption patterns).
 25493 *Transition movements* pathways also develop bottom-up transformative capabilities by combining
 25494 rights-based instruments and customary norms (including indigenous and local knowledge) and social
 25495 and information instruments (*established but incomplete*) (5.5.3, 5.5.4). The sets of actions proposed
 25496 in the pathways are not mutually exclusive and can be combined. For example, actions from *green*
 25497 *economy* and *low carbon transformation* pathways may pave the way towards more transformative
 25498 *transition movements* pathways. Moreover, future transitions to sustainability may be fostered
 25499 through cross-scale integration and mainstreaming of environmental issues into sectoral policies and
 25500 decisions, along with nurturing diverse social, institutional and technological experiments (*established*
 25501 *but incomplete*) (5.5.5).

25502 **Participatory scenario, vision and pathway development is a powerful approach for knowledge co-**
 25503 **production and has great potential for the explicit inclusion of indigenous and local knowledge**
 25504 **(established but incomplete) (5.4.3, 5.5.1, 5.5.2, 5.5.6, 5.6.2).** Many scenario, vision and pathways
 25505 exercises include local stakeholders and their valuable knowledge and practices. However, the use of
 25506 different knowledge systems, such as indigenous and local knowledge, was rarely explicitly mentioned
 25507 in studies (5.6.2). Explicit examples that included indigenous and local knowledge (see **Boxes 5.2, 5.6**
 25508 **and 5.10**), show a clear added value from combining different forms of knowledge with technological
 25509 innovations, and cultural diversity, norms and customary rights when pursuing goals of sustainable
 25510 development (5.2.2, 5.5.2, 5.5.3, 5.5.6).

25511 **Knowledge gaps and resulting uncertainties in exploring future interactions between nature and**
 25512 **society are substantial because integrated assessments of future impacts on nature, nature's**
 25513 **contributions to people and a good quality of life that take account of the complex**
 25514 **interdependencies in human and environmental systems are rare (well established) (5.6.2).** Very few
 25515 studies were available for Central Asia and to a lesser extent for Eastern Europe (*well established*)
 25516 (5.6.2). Less information was also available for marine systems than for terrestrial and freshwater
 25517 systems (*well established*) (5.6.2). Few integrated scenario and modelling studies include indicators of
 25518 nature's non-material contributions to people and good quality of life (5.3.2, 5.5.1, 5.6.2) and therefore
 25519 existing assessments of synergies and trade-offs are limited in the interactions and feedbacks they
 25520 represent (*well established*) (5.3.2). No studies were found that assessed future flows of nature's
 25521 contributions to people across countries, which would have been important to assess the impacts of
 25522 the scenarios and pathways for Europe and Central Asia on other parts of the world (*well established*)
 25523 (5.6.2). There is also a significant gap in the current literature in recognizing the diversity of values,
 25524 with the focus being mainly on instrumental values (*well established*) (5.6.2). Finally, scenario and
 25525 modelling studies include many uncertainties in their projections of the future resulting from input
 25526 data, scenario assumptions, model structure and propagation of uncertainties across the integrated
 25527 components of the systems, which should be borne in mind when interpreting their results (*well*
 25528 *established*).

5.1 Introduction

5.1.1 Chapter aims and structure

Nature and human society interact in complex ways as illustrated in the IPBES conceptual framework (IPBES, 2016a). For example, biodiversity underpins many of nature's contribution to people (NCP) but, at the same time, human development has caused significant losses in biodiversity through overexploitation and other drivers of change. Indirect drivers of biodiversity loss include human population change, economic development and policy or institutional change. These influence direct drivers, such as land use patterns or climate change, which in turn affect nature and its ability to deliver its contributions to people which support a good quality of life (Díaz et al., 2015; Hauck et al., 2015; Rounsevell & Harrison, 2016). The complex interactions result in significant uncertainties that make it difficult for societies to resolve an appropriate course of collective action to adapt to or to mitigate change and to pursue sustainable livelihoods (Rounsevell et al., 2010). Despite these uncertainties and complex interactions, it is important to understand at least key interrelationships to develop effective management and policy strategies (Luck et al., 2009).

However, social, economic and political conditions in the future may be very different from today. Scenarios and models provide a means for exploring uncertainties about how different drivers of change might develop in the future and for considering how those changes might alter society's vulnerability and ability to take action. Scenarios describe possible futures for drivers of change or policy interventions. These are then translated into projected consequences for nature, nature's contributions to people, and good quality of life by models (IPBES, 2016c). This improves understanding of the range of plausible futures in a region, alerts decision-makers to undesirable future impacts, and enables exploration of the effectiveness of policy options and management strategies. Thus, scenarios and models can contribute to the decision support that is needed for proactively developing policy that anticipates change and thereby minimizes adverse impacts and capitalizes on opportunities through insightful adaptation, mitigation and transformation strategies (adapted from IPBES/2/17: Report of the second session of the Plenary of the Intergovernmental Science-policy Platform on Biodiversity and Ecosystem Services, Annex VI: Initial scoping for the fast-track the IPBES Methodological Assessment on Scenarios and Models of Biodiversity and Ecosystem Services IPBES (2016c)).

Scenarios are often categorized into two main types: exploratory and normative (but also see, for example, IPBES (2016c); Rounsevell & Metzger (2010)). Exploratory scenarios describe a range of plausible futures based on assumptions about how trajectories of indirect and direct drivers may change (**Figure 5.1A**). They are particularly useful for the agenda-setting phase of the policy cycle in understanding "what might happen in the future". Normative or target-seeking scenarios are used to appraise alternative policy choices or management interventions (**Figure 5.1B**). They are useful for the policy design phase of the policy cycle in evaluating "what actions decision-makers can take to move away from undesirable futures towards more sustainable futures". This latter type of scenario is often related to a goal or vision of a desirable future, which represents the target for adaptation, mitigation and transformation actions. The normative scenario then describes different pathways (which consist of policy choices or management interventions) that might achieve the vision of the desired future. We focus on visions of sustainable development and the pathways for moving society towards such a sustainable future.

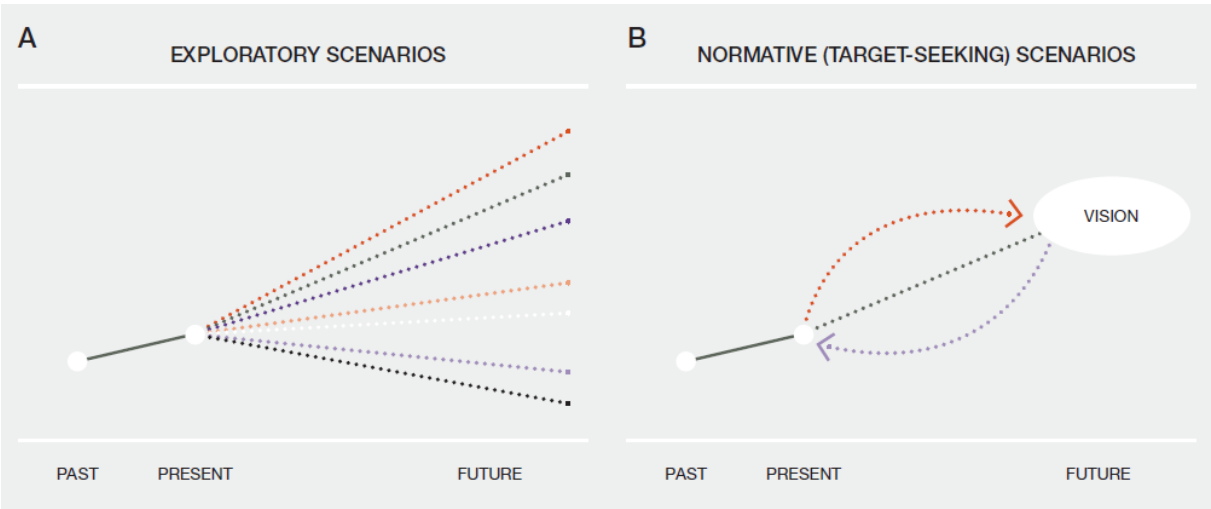


Figure 5.1: Illustration of (A) exploratory scenarios; and (B) normative or target-seeking scenarios. Adapted from IPBES (2016c).

Chapter 5 is divided into two parts reflecting these two different types of scenarios (Figure 5.2). The first part describes the range of plausible futures for Europe and Central Asia based on a review of exploratory scenarios (Section 5.2). The consequences of these futures for nature, its contributions to people, and good quality of life, as simulated by models, are described in Section 5.3. This first part provides an assessment of what might happen in the future taking account of uncertainties in projections of different drivers of change. It provides the foundation for understanding the key challenges that may be faced by society in moving towards a more sustainable future. The second part of the chapter describes what a sustainable future might look like by reviewing different visions of sustainable development and how these relate to the United Nations 2030 Agenda for Sustainable Development and the Sustainable Development Goals (SDGs), the Strategic Plan for Biodiversity 2011-2020 and its Aichi Biodiversity Targets, and the long-term European Union Biodiversity Strategy for 2050 (Section 5.4). Possible pathways for achieving such visions are then appraised in Section 5.5 based on a review of pathways and normative scenarios. This analysis provides an assessment of the alternative policy choices or management interventions that can be used by decision-makers to move towards meeting sustainability goals. In so doing, it supports a good quality of life for the people of Europe and Central Asia by mitigating biodiversity loss and promoting a balanced supply of nature’s contributions to people.

As Chapter 5 takes an integrated approach to assessing the relationship between nature and society, it reflects all the boxes and flows of the IPBES conceptual framework (IPBES, 2016b): nature, its contributions to people, and a good quality of life, and how they are influenced by natural and anthropogenic direct drivers as well as institutions and governance and other indirect drivers. Furthermore, it builds on the analysis presented in the previous chapters of this report, particularly the assessment of the impacts of scenarios on nature’s contributions to people in Chapter 2 and nature in Chapter 3, and the assessment of indirect and direct drivers in Chapter 4 (Figure 5.2). In addition, Chapter 6 builds on the findings in this chapter by considering the options for governance, institutional arrangements, and private and public decision-making for implementing the future policy responses analyzed in the scenario and modelling studies (Figure 5.2).

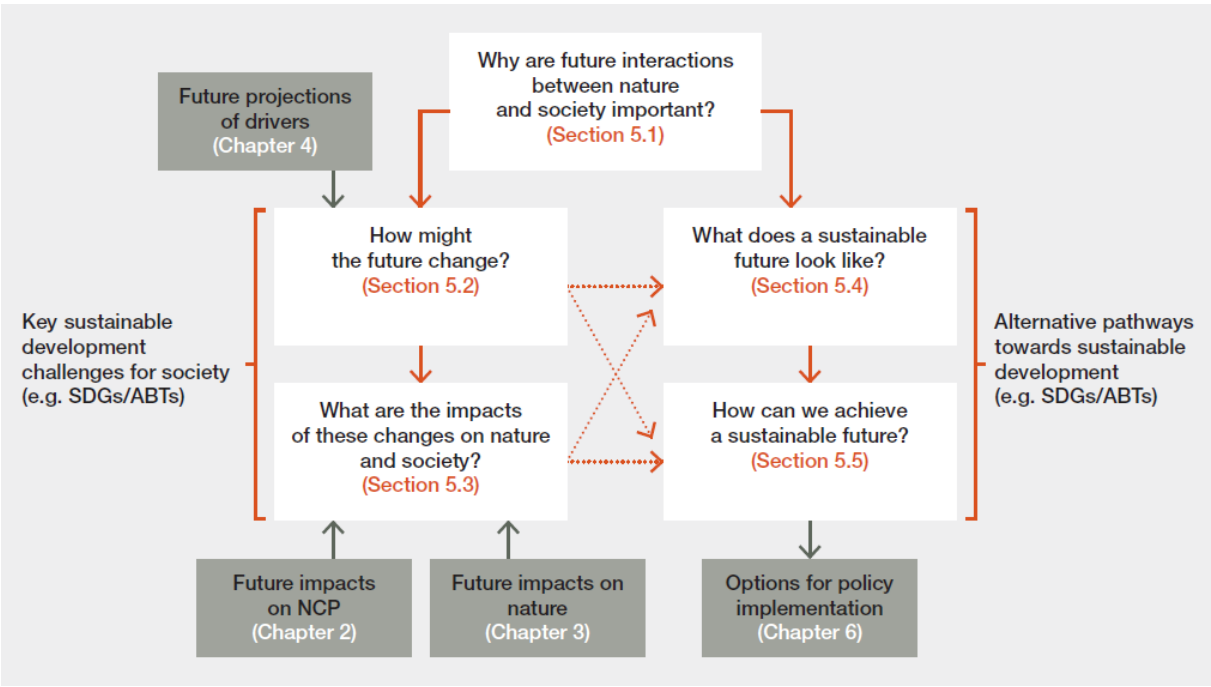


Figure 5.2: Schematic showing the key questions addressed in Chapter 5 and how these relate to the chapter structure. Links to other chapters in the Regional Assessment for Europe and Central Asia are also shown. SDGs = Sustainable Development Goals; ABTs = Aichi Biodiversity Targets.

Box 5.1: Key definitions in Chapter 5

“Scenarios” are consistent and plausible pictures of possible futures (in line with Chapter 1 and IPBES (2016c). “Exploratory scenarios” examine a range of plausible futures based on assumptions about a range of trajectories of indirect and direct drivers. “Normative scenarios”, sometimes referred to as policy or target-seeking scenarios, explore the consequences of specific policy choices or management interventions.

“Models” are qualitative or quantitative representations of key components of a system and of relationships between these components. Throughout this chapter the term “models” usually, but not exclusively, refers to quantitative descriptions of relationships between drivers (indirect and direct) and nature (biodiversity and ecosystems), nature’s contributions to people (ecosystem services) and a good quality of life (human wellbeing).

“Integrated assessment models” combine modelling of multiple environmental, social and economic system components and their interactions.

“Visions” are descriptions of a desirable future (an endpoint in time), which society or parts of society want to achieve. They usually consist of statements depicting orienting goals, and the assumptions, beliefs and paradigms that underlie the desired future. Visions can take the form of policy targets, but can also be formulated by a range of actors, e.g. from the private sector to address business targets or civil society to address social targets.

“Pathways” consist of descriptions of different strategies for moving from the current situation towards a desired future vision or set of specified targets. They are descriptions of purposive courses of actions that build on each other, from short-term to long-term actions into broader transformation. They are closely related to normative or policy or target-seeking scenarios.

END OF BOX 5.1

5.1.2 Framing futures in the context of global sustainability targets and policy goals

Futures analysis can contribute to decision support in relation to major policy goals and targets. Europe and Central Asian Governments were among the 193 Member States of the General Assembly of the

United Nations that adopted the “2030 Agenda for Sustainable Development” in 2015; and the Parties to the Convention on Biological Diversity that adopted the “Strategic Plan for Biodiversity 2011-2020” in 2010. Both documents are framed by visions and structured around key strategic goals (see Section 1.4), which represent priority areas for action and provide guidance for policy decisions and for the establishment of strategic plans at national and regional levels.

While the Sustainable Development Goals and Aichi Biodiversity Targets are shared globally, not all of them are formulated, nor expected to be equally relevant, for all countries or sectors. Activities to reach goals and targets can be tailored to the specific needs and visions of countries and sectors (CBD, 2010). Nonetheless, strictly focusing on those targets which are directly relevant for a specific sector or region bears the risk of causing unexpected trade-offs, or missed synergies, between targets (UNEP, 2015). This could potentially lead to conflicts between visions sharing the common goal of sustainable development. Analysis of how the Sustainable Development Goals and Aichi Biodiversity Targets are represented in regional (European and Central Asian) and global visions provides a framework for assessing the current coherence in policy goals across regional to global scales and sectors.

The cross-scale coherence between goals defined within visions of sustainable development globally and within the region of Europe and Central Asia are shown in **Figure 5.3** (see Section 5.4 for further information on the review underlying this figure). There are similarities, but also key differences, in the extent to which key sustainability goals and targets, such as the Sustainable Development Goals and Aichi Biodiversity Targets, are mainstreamed in global vs regional visions. Both global and regional visions prioritize Goal 12 of the Sustainable Development Goals (responsible consumption and production), Goal 13 (climate action) and Goal 15 (life on land). Biophysical values are also well represented in the visions at both levels, indicating a strong emphasis on environmental issues in the sustainability visions. However, visions for Europe and Central Asia place greater emphasis than global visions on Goal 8 (decent work and economic growth), Goal 9 (industry), Goal 7 (clean energy) and goal 11 (sustainable cities). In contrast, visions for Europe and Central Asia put less priority on Goal 10 (reduced inequalities), Goal 3 (health), Goal 5 (gender equality) and Goal 16 (peace, justice and strong institutions).

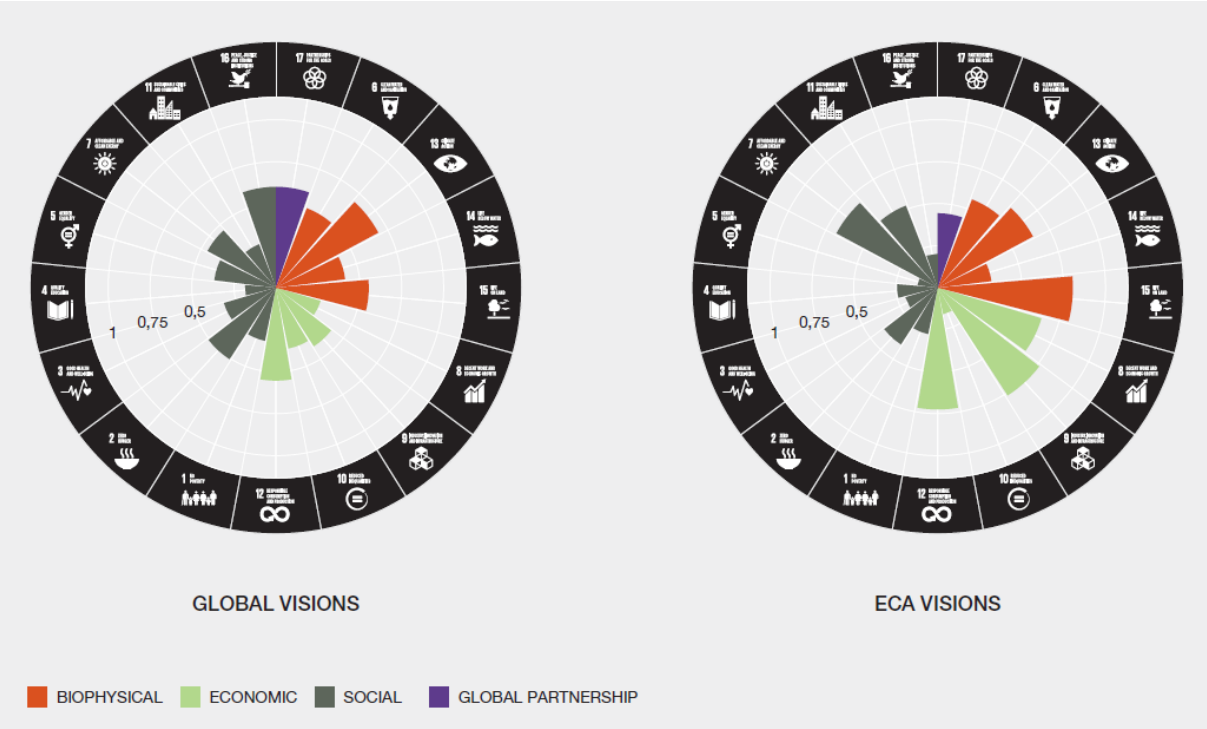


Figure 5.3: Coverage of goals similar to the Sustainable Development Goals by global (number of analyzed visions = 22) and Europe and Central Asia (ECA) (number of analyzed visions = 25) visions of sustainable development. Dimensions of sustainability were assigned to Sustainable Development Goals based on their dominant character (Folke et al. 2016). The size of the bar towards each Sustainable Development Goal shows the proportion of visions covering that Goal, ranging from 0 (not mentioned) to 1 (covered by all visions). Note the visions often concern a different (longer-term, beyond 2030) timescale to the Sustainable Development Goals.

The coverage of targets similar to the Aichi Biodiversity Targets by the visions is limited at both the global and European and Central Asia levels (**Figure 5.4**), with only a few of the 20 targets being covered. An overall narrowing of biodiversity concerns towards indirect (Target 4) and direct pressures (Target 7) is shown in visions for Europe and Central Asia. In particular, market pressures from consumption patterns and direct pressures from agriculture, aquaculture and forestry activity suggest a strong regional priority on actions to mitigate the cause of environmental impacts (Strategic Goals A and B, see Section 1.4).

This analysis provides an overview of the policy priorities for Europe and Central Asia in comparison to global policy priorities. In the rest of this chapter, we use the insights gained from scenario, modelling and pathway studies to appraise (i) the likelihood of achieving goals similar to the Sustainable Development Goals and Aichi Biodiversity Targets under different plausible futures for Europe and Central Asia; and (ii) the policy options and management interventions which may potentially hinder or support the achievement of such goals. We do this by synthesizing knowledge on the future dynamics of biodiversity, ecosystem functions and nature's contributions to people that affect their contribution to the economy, livelihoods and quality of life in Europe and Central Asia (question 2 in IPBES/4/INF/9: Guide on the production and integration of assessments from and across all scales; see Chapter 1, Section 1.1.1. Our analyses of exploratory scenario and modelling studies show the effects of production, consumption and economic development on biodiversity, nature, and its contributions to people and to a good quality of life (Europe and Central Asia-specific question 7; see Chapter 1, Section 1.1.1, while our analyses of pathways studies highlight the role of investments, regulations and management regimes in protecting nature and nature's contributions to people (Europe and Central Asia-specific question 6; see Chapter 1, Section 1.1.1). In all our analyses, it should be recognized that futures studies concern longer time horizons than the deadlines for targets set within the Aichi Biodiversity Targets and Sustainable Development Goals, often to 2050, and hence they provide guidance on longer-term policy planning.

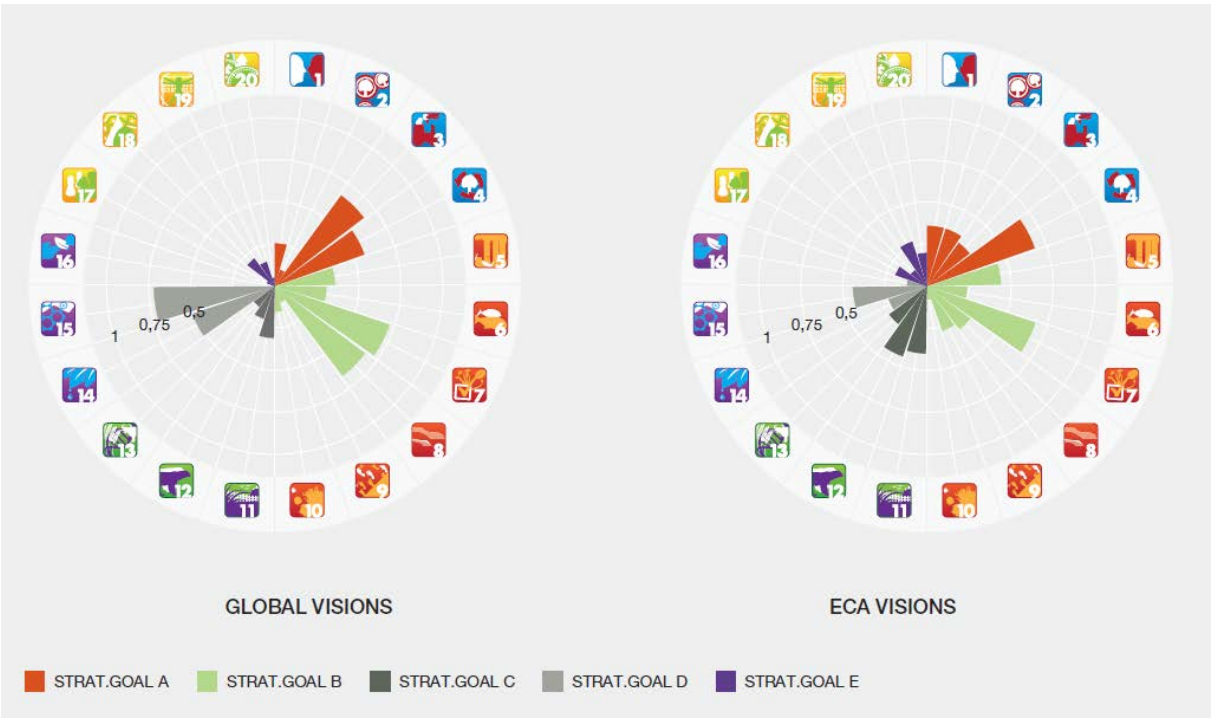


Figure 5.4: Coverage of goals similar to the Aichi Biodiversity Targets within global (number of analyzed visions = 22) and Europe and Central Asia (ECA) (number of analyzed visions = 25) visions of sustainable development. Aichi Biodiversity Targets are organized by strategic goal of the Strategic Plan for Biodiversity 2011-2020, each goal addressing an area for action (A - the underlying causes of biodiversity loss, B - the direct pressures on biodiversity, C - the status of biodiversity, D - the benefits from biodiversity and ecosystem services, and E - implementation of biodiversity strategies and action plans). The size of the bar towards each Aichi Biodiversity Target shows the proportion of visions covering that target, ranging from 0 (not mentioned) to 1 (covered by all visions). Note the visions often concern a different (longer-term, beyond 2020) timescale to the Aichi Biodiversity Target, which is more in line with the 2050 timescale of the vision of the Strategic Plan.

5.2 Plausible futures for Europe and Central Asia

Chapter 4 assessed past, current and future changes in indirect (demographic, economic, scientific and technological, cultural and institutional) and direct drivers (climate change, land use/cover change, natural resource extraction, pollution and invasive alien species). Here we build on this assessment of individual drivers by reviewing exploratory scenarios which attempt to combine consistent changes in multiple indirect and direct drivers, including the effect(s) of indirect drivers on direct drivers, such as socio-economic impacts on land use (see Oosterwind et al. (2016)). Such scenarios portray a range of plausible futures for a region. Understanding the different ways in which the future might develop is helpful for identifying problems, evaluating and changing current thinking and improving decision-making. In this respect, exploratory scenarios set the context for assessing the robustness of future decisions on nature protection and sustainable development. They also facilitate the integration of knowledge across drivers, sectors, actors and disciplines stimulating solutions-oriented “out-of-the-box” thinking.

Section 5.2 describes different plausible futures for Europe and Central Asia, by reviewing exploratory scenarios for the region. These scenarios are subsequently grouped into broad categories of similar scenarios known as scenario archetypes. Projected future changes in the different indirect and direct

drivers represented within the exploratory scenarios for Europe and Central Asia are described for each scenario archetype. This provides a rich picture of the types of futures that may occur for the region and the uncertainties associated with them. Such regional scenario archetypes are helpful for assessing the implications of future drivers of change on nature, its contributions to people, and a good quality of life using models (see Section 5.3 where these impacts are discussed). The relationship between the assessment of exploratory scenarios in Section 5.2 and the assessment of modelling studies in Section 5.3 is illustrated in **Figure 5.5**.

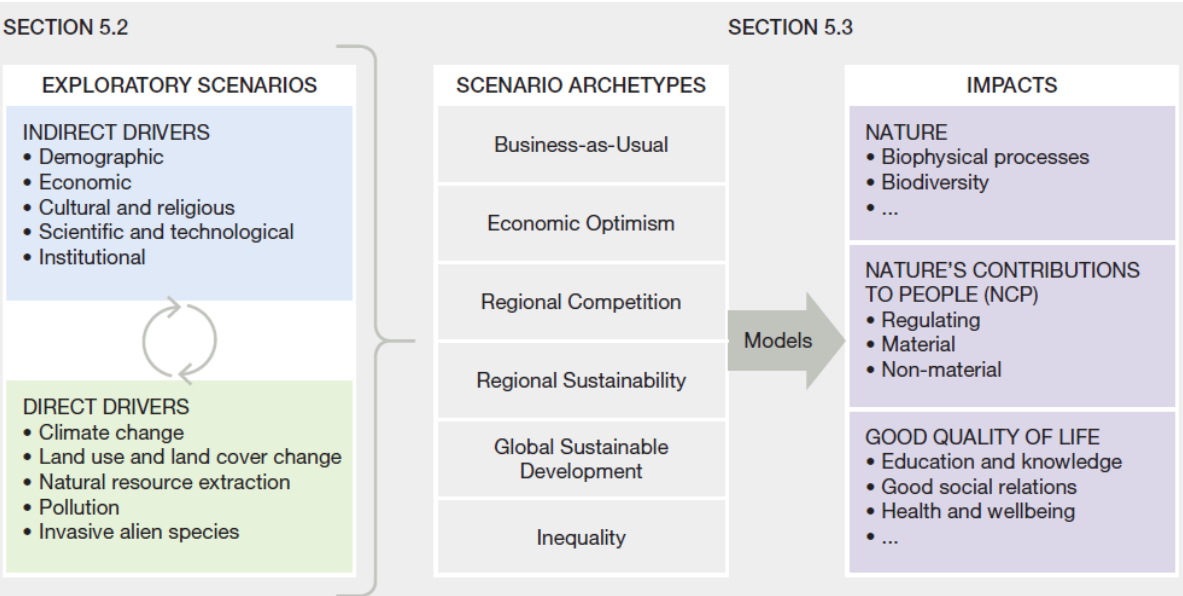


Figure 5.5: Schematic showing how individual indirect and direct drivers are combined in exploratory scenarios, which in turn are categorized into scenario archetypes for the assessment of impacts on nature, nature’s contributions to people, and a good quality of life using models.

5.2.1 Review of exploratory scenarios for Europe and Central Asia

A formal review of exploratory scenarios was carried out based on peer-reviewed scenario literature for Europe and Central Asia using the Scopus database. This was supported by an informal review of grey literature using the knowledge of the author team. Both reviews focused on environment-related scenarios from 2005 until the present. Articles were screened for the ten aggregated groups of drivers defined in Chapter 4, and their interactions (**Figure 5.5**). Studies including only single drivers and studies with subnational spatial coverage were excluded from the review. These constraints were put in place to focus on multiple driver combinations (as single drivers are dealt with in Chapter 4) and on spatial scales relevant to the subregional and regional levels (but see **Box 5.2** for examples of local scenario studies).

A total of 436 scenarios in 143 studies from both the formal and informal reviews met the review criteria and were assessed. This section briefly describes the review database in terms of its coverage of regions, sectors, drivers and values.

Regional coverage: The majority of studies originated from Western (64%) and Central Europe (30%), with many fewer studies from Eastern Europe (5%) and Central Asia (1%). Most scenario studies covered a specific geographic region, and examples of multi-scale or cross-scale scenarios were rare (Kok & Pedde, 2016).

25746 *Sectoral coverage:* More of the scenario studies focused on single (59%) than on multiple (41%) sectors
 25747 (**Figure 5.6a**). Most of the single sector studies considered the water sector (21%; e.g. (Flörke et al.,
 25748 2012; Kok et al., 2011; Nunneri et al., 2007), followed by the agricultural sector and food production
 25749 (18%; e.g. (Rozman et al., 2013; Uthes et al., 2009; Wirsenius et al., 2010). Sectors such as forestry,
 25750 energy, health and fisheries were only covered by a limited number of scenarios (2-8%). Nature
 25751 conservation as a single sector was only addressed in three studies, which developed scenarios based
 25752 on the Intergovernmental Panel on Climate Change Special Report on Emissions Scenarios (IPCC SRES)
 25753 (Nakicenovic et al., 2000) and applied these to land use change and species distribution models
 25754 (Kolomyts, 2006; Louca et al., 2015; Pont et al., 2015). However, biodiversity and nature's
 25755 contributions to people were covered in several of the multi-sector scenario studies (e.g. Grazhdani,
 25756 2014; Haines-Young et al., 2011; Okruszko et al., 2011; Pereira et al., 2009).

25757 *Driver coverage:* The vast majority of studies (approximately 80%) covered up to six drivers out of the
 25758 ten categories of direct and indirect drivers defined in Chapter 4. The scenarios that considered six or
 25759 more driver categories frequently belonged to large-scale assessments (e.g. (CBD/MNP, 2007; Haines-
 25760 Young et al., 2011; Millennium Ecosystem Assessment, 2005; Reder et al., 2013; van Wijnen et al.,
 25761 2015)) (**Figure 5.6b**) or a small set of European Union scenario studies developed within large-scale
 25762 research projects (e.g. ALARM (Chytrý et al., 2012; Spangenberg et al., 2012; Vogiatzakis et al., 2015);
 25763 CLIMSAVE (Audsley et al., 2015; Harrison et al., 2015; Kok et al., 2013); EURuralis (Eickhout et al., 2007;
 25764 Verboom et al., 2007; Verburg et al., 2010); IMPRESSIONS (Kok & Pedde, 2016); OpenNESS (Hauck et
 25765 al., 2017); SCALER (Edjabou & Smed, 2013; Milestad et al., 2014); SCENES (Flörke et al., 2012; Okruszko
 25766 et al., 2011; Reder et al., 2013)).

25767 In most cases, the reviewed studies examined combinations of demographic, economic and
 25768 technological drivers (approximately 60% of the studies; **Figure 5.6c**), or combined these drivers with
 25769 climate change (more than 40% of studies), land use change (approximately 26% of the studies) or
 25770 natural resource extraction (approximately 18%). This illustrates that the studies commonly built on
 25771 the IPCC SRES scenarios, combining these categories of drivers, as the basis for further analysis (e.g.
 25772 (De Vries & Posch, 2011; Murray-Rust et al., 2013; Reidsma et al., 2006; Rounsevell et al., 2006)). The
 25773 newer IPCC *shared socioeconomic pathways* (SSPs) (O'Neill et al., 2015), which focus on a similar set
 25774 of drivers, were applied to a more limited extent due to their recent finalization (e.g. (Blanco et al.,
 25775 2017; Popp et al., 2017; Riahi et al., 2017)).

25776 Among cultural drivers, the impact of diet (including the degree of meat consumption or food origin)
 25777 was commonly examined, e.g. on greenhouse gas emissions (Fazeni & Steinmüller, 2011; Stehfest et
 25778 al., 2009), water use (Vanham et al., 2013), nutrient emissions (Thaler et al., 2015) and land use change
 25779 (Milestad et al., 2014; Wirsenius et al., 2010). The interaction of institutional change with other drivers,
 25780 was generally understudied, with some exceptions (Haines-Young et al., 2011; Kok et al., 2011; Kok &
 25781 Pedde, 2016; Millennium Ecosystem Assessment, 2005; Milestad et al., 2014; Reder et al., 2013;
 25782 Strokhal et al., 2014).

25783 From the perspective of direct drivers, scenario studies were strongly dominated by climate change,
 25784 followed by land use and land cover change (Mitchley et al., 2006). Scenarios including both climate
 25785 and land use change were frequently linked to the role of agriculture as a driver of landscape change
 25786 (Eitzinger et al., 2013; Eliseev & Mokhov, 2011; Louca et al., 2015; Nol et al., 2012; Pukšec et al., 2014;
 25787 Thaler et al., 2015) (**Figure 5.6c**). However, the proportion of land use change scenario studies that
 25788 explicitly examined impacts on biodiversity was small relative to empirical studies showing that land
 25789 use change is one of the most important past drivers of changes in biodiversity and nature's
 25790 contributions to people in Europe and Central Asia (see Chapter 4, Section 4.5, and WWF Living Planet
 25791 Report 2016 (WWF, 2016)). Different levels of protection (Chytrý et al., 2012; Haines-Young et al.,

2011) and degrees of fragmentation (Haines-Young et al., 2011; Milestad et al., 2014) were frequently considered in the reviewed scenarios. Yet, they were mostly related to pressures exerted on land use by policy, social, economic or climatic drivers, rather than as a driving force on nature and its contributions to people. These results are consistent with the finding by (Titeux et al., 2016) that within biodiversity-related scenarios, compared to climate change, the impact of land use change is often neglected. Other direct drivers, such as pollution, natural resource extraction and invasive alien species, with adverse impacts on biodiversity and nature's contributions to people, were poorly represented in scenarios. While some pollution aspects such as the impact of nutrient emissions (phosphorous and nitrogen in fertilizers) on marine and freshwater ecosystems were frequently studied (Håkanson & Bryhn, 2014; Holguin-Gonzalez, 2014; Nol et al., 2012; Nunneri et al., 2007; Seitzinger et al., 2010), others were greatly understudied (e.g. the impact of nanoplastics; (Ryan et al., 2009)).

Finally, there were very few scenario studies which modelled feedbacks from direct drivers, such as climate change or land use change, to socio-economic trends (an integral component of the IPBES conceptual framework (Díaz et al., 2015)), highlighting a key gap in the scientific literature covering nature's contributions to people.

Values coverage: The concept of value (see Chapter 1, Section 1.5.2 for the definition of “value” within IPBES) was only considered in 30% of scenario studies in Europe and Central Asia, with 19% including values explicitly and 11% implicitly. For example, Verburg et al. (2008) included the concept of value explicitly when analyzing how changes in demand for agricultural products are likely to have a large impact on landscape quality and the value of natural areas. In contrast, Mitchley et al. (2006) considered the values concept implicitly through an assessment of how trends in agricultural systems result in negative impacts on biodiversity. Studies included different dimensions of value: 66% used the concept of value as nature's contributions to people (i.e. anthropocentric instrumental values); 26% as nature (non-anthropocentric or intrinsic values); and 8% as good quality of life (anthropocentric relational values). Most studies focused primarily on values associated with material contributions to people (44%), followed by regulating and supporting contributions (39%), then non-material contributions (17%). The purpose or target of valuation within the scenario studies covered agriculture (22%), spatial planning (20%), biodiversity and conservation (19%), and climate change (18%).

These findings show that only a minority of scenario studies take account of the value of nature, its contributions to people, and good quality of life (Murray-Rust et al., 2013). They also indicate that most studies addressed the different dimensions of value only independently (e.g. Millennium Ecosystem Assessment, 2005) or linked nature with a limited set of mainly instrumental values, excluding other dimensions such as intrinsic or relational values. This highlights a significant gap in the current scenario literature in recognizing the diversity of values (e.g. IPBES (2016c)). Closing this gap could be of particular importance as the transformative practices that may be needed for achieving sustainable futures can benefit from embracing such value diversity (Pascual et al., 2017) (see Section 5.5).

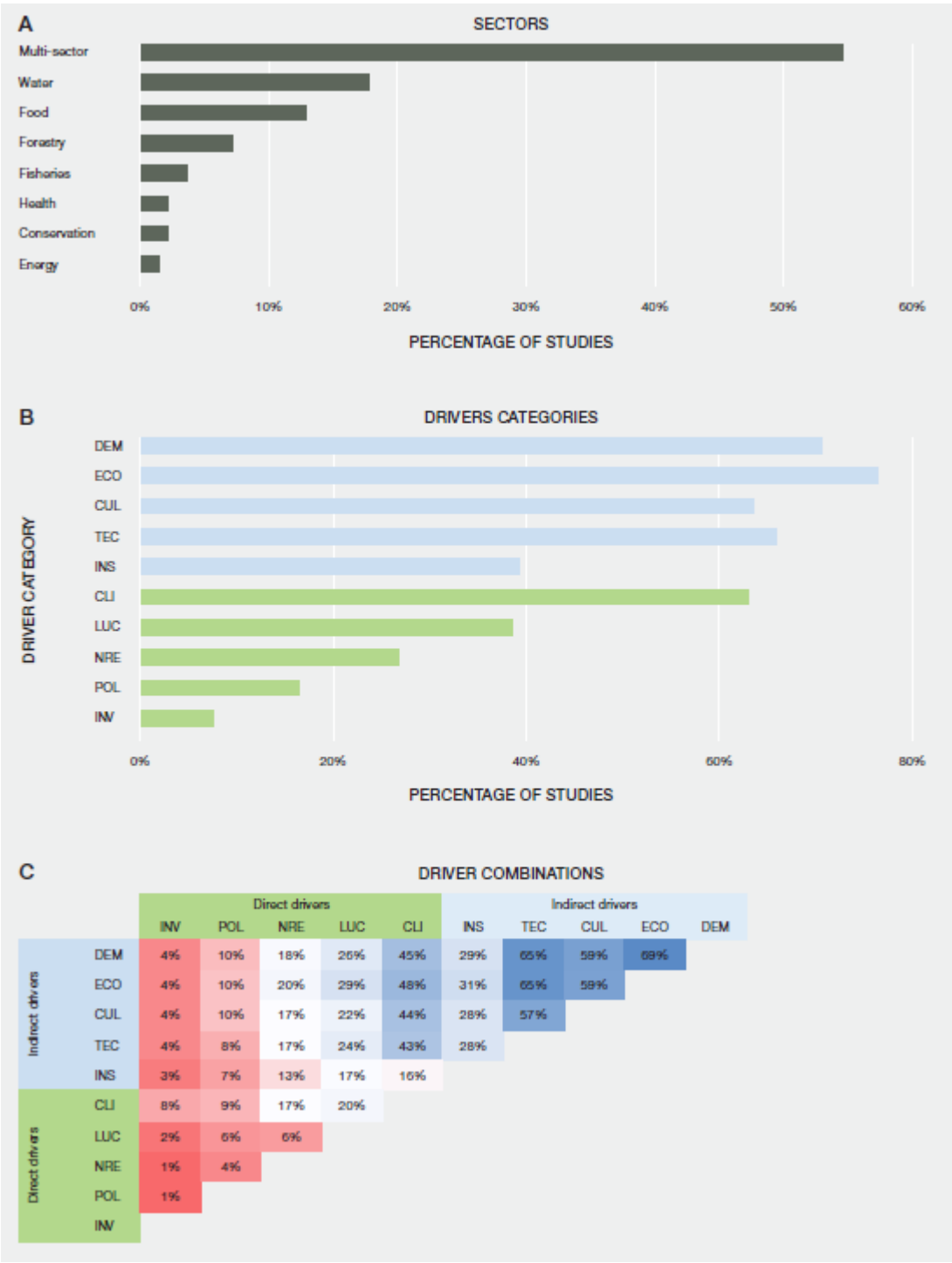


Figure 5.6: Representation of (a) sectors, (b) driver categories, and (c) driver combinations (all as a percentage of 143 reviewed studies). Legend to driver abbreviations: DEM = demographic, ECO = economic, CUL = cultural & religious, TEC = scientific & technological, INS = institutional, CLI = climate change, LUC = land use/cover change, NRE = natural resource extraction, POL = pollution, INV = invasive alien species. In (c), the percentage of studies covering each driver combination is color-coded (blue shading for a greater number of studies through to red shading for low numbers of studies).

Box 5.2: Local participatory scenario planning

A plethora of local-scale scenario studies have been conducted in Europe and Central Asia, predominantly in Western and Central Europe. While this section focuses on assessing scenario studies of subregional and regional relevance, this box briefly illustrates the richness of local-scale scenario approaches and their applications. The development of local scenarios typically involves key stakeholders and their local knowledge in the process of participatory scenario planning, in which participants and researchers collaborate to characterize a selected social-ecological system and plan for its future. Local-scale scenarios can also be used to model the effect of both large-scale and local-scale driving forces on nature and its contributions to people. Furthermore, they have the potential to facilitate the creation of bottom-up pathways for sustainable development (see **Box 5.10** in Section 5.5).

Central Europe: Bottom-up participatory approaches have been utilized in several Central European case studies to identify how driving forces at multiple scales influence local social-ecological systems. For example, a case study from southern Transylvania, Romania, presents a novel holistic approach for identifying future opportunities and risks (Hanspach et al., 2014) (see also **Box 5.10**). In another case study, conducted in the Třeboň Basin UNESCO Biosphere Reserve, the Czech Republic, local narratives were combined with existing European Union scenarios to assess potential future trade-offs among nature's contributions to people (Harmáčková & Vačkář, 2015). In both cases, the results suggest that the main opportunities for the future of the study regions lie in maintaining and carefully capitalizing on their high natural capital and cultural heritage, e.g. through promoting biodiversity conservation and ecological and cultural tourism. Sustainability-related conclusions are central also to a case study from the Municipality of Koper, Slovenia, illustrating a substantial impact of industrial and commercial development on the loss of high quality agricultural land and the perceived quality-of-life (Murray-Rust et al., 2013).

Western Europe: Multiple case studies undertaking place-based, participatory scenario planning in Western Europe, are included in a comprehensive review by Oteros-Rozas et al. (2015). These include the Peak District National Park, England (Reed et al., 2013), Doñana National Park, Spain (Palomo et al., 2011), the Conquense Drove Road, Spain (Oteros-Rozas et al., 2013), and the French Alps (Lamarque et al., 2013). The authors find that participatory scenario planning, when tailored to the local social-ecological context, results in improved environmental management and fosters scientific research. Other local scenarios were used to model how farmers' decisions are shaped by various factors (e.g. subsidies, social relationships, the need to prioritize food or biofuels) and how this influences land use patterns and species' populations, such as in the cases of the Lunan catchment, Scotland, and the Montado, Portugal, (Acosta-Michlik et al., 2014; Guillem et al., 2015).

Eastern Europe and Central Asia: Participatory approaches are particularly suited to regions where resource constraints or knowledge gaps from expert-based sources are prevalent. Several case studies document the use of interviews and local participatory methods. For example, Kamp et al. (2015) employed a qualitative methodology comprising farmer interviews to examine the impact of diverse agricultural land management approaches on bird populations in Kazakhstan. This study revealed that, under the assumption of increasing agricultural production, intensification of existing cropland rather than conversion of abandoned land would have the least impact on avian biodiversity. Participatory approaches are also essential where governance and other regulatory apparatus have a weak influence and agreement among local stakeholders is key in achieving a desirable outcome. Schwilch et al. (2009) document how these approaches have been employed within the fight to mitigate desertification in Turkey and the Russian Federation through promotion of sustainable land management practices in local stakeholder workshops.

END OF BOX 5.2

5.2.2 Types of plausible futures for Europe and Central Asia

To synthesize findings from the plethora of existing scenario studies, scenarios may be grouped into several "scenario families" or "scenario archetypes" according to their underlying assumptions, storylines and characteristics (**Box 5.3**). Scenario archetypes describe different general patterns of future developments and can be useful in summarizing and harmonizing the overwhelming amount of information in individual sets of scenarios. The scenario archetype approach has been recognized by

IPBES (IPBES 2016a) to help to synthesize findings from scenarios throughout the four IPBES regional assessments. In addition, the use of scenario archetypes will facilitate a coherent comparison of scenarios across the regional assessments and their further synthesis in the IPBES Global Assessment on Biodiversity and Ecosystem Services. Consequently, IPBES (2016c) proposed a set of six global scenario archetypes based on scenario families described by van Vuuren et al. (2012).

To synthesize the exploratory scenarios reviewed for Europe and Central Asia, six IPBES scenario archetypes were selected:

1. Business-as-usual
2. Economic optimism
3. Regional competition
4. Regional sustainability
5. Global sustainable development
6. Inequality

These include five archetypes from IPBES (2016c); numbered 1 to 5 above. “Reformed markets” from IPBES (2016c) was omitted since, at the sub-global level, it is mostly synonymous with a change to more sustainable policies, and therefore falls within the *global sustainability* development archetype. An additional *inequality* scenario archetype (not included in IPBES (2016c)) was added reflecting the growing importance of this archetype in the scenario literature (see **Box 5.3**).

The scenario archetypes are described in detail in the following section. The six archetypes are not represented equally in the literature for Europe and Central Asia. The *business-as-usual* type of scenario is often used as a reference scenario (30% of scenarios). However, few of these studies develop a storyline of how indirect and direct drivers are projected to change over time (only three studies), rather they simply assume no change in current trends. *Economic optimism* is well-represented (24%) possibly due to its overlap with *business-as-usual* and the popularity of downscaled regional versions of the Intergovernmental Panel on Climate Change SRES A1B and A1FI scenarios (Nakicenovic et al., 2000). *Regional competition* (17%), *global sustainable development* (14%) and *regional sustainability* (12%) are reasonably well represented in European and Central Asian scenario studies. By contrast, *inequality*, as a relatively new scenario developed as part of the recent Intergovernmental Panel on Climate Change-related SSPs (O'Neill et al., 2015), is only covered in 2% of scenario studies, but this is expected to increase rapidly.

Box 5.3: Scenario archetypes: comparing global archetypes with archetypes for and Europe and Central Asia

The approach of categorizing similar scenarios into “scenario archetypes” based on their underlying assumptions, characteristics and narratives, is particularly useful to summarize and harmonize large numbers of existing scenarios covering a particular area and period. This approach has been previously applied by scenario reviews at multiple scales. For instance, at the global scale, a review by van Vuuren et al. (2012) proposed six “scenario families” (**Table 5.1**). In another study, Rothman (2008) provided a detailed and conceptually grounded overview of a number of archetypes found in environmental scenarios covering a broad range of sectors, scales and types. Both of these are in general agreement with other similar studies (e.g. Busch (2006); Westhoek et al. (2006); Zurek (2006)). In addition, there are scenario archetype studies that predominantly review subglobal studies, for example, a review of more than 160 local scenario studies by Hunt et al. (2012). Although none of these review papers specifically targeted nature or its contributions to people, they did consider the most influential scenario studies on these topics, including the Millennium Ecosystem Assessment (Millennium Ecosystem Assessment, 2005) and multiple land use change scenarios (see Busch, 2006).

25932 All of the studies presented above largely agree on similar, comprehensive sets of four to seven scenario
 25933 archetypes (**Table 5.1**). Furthermore, they all single out one particular set of scenarios in their analysis, namely
 25934 the “global scenario group” scenarios (van Vuuren et al., 2012), as being helpful to centre the scenarios around.

25935 **Table 5.1: Six global scenario families as proposed by van Vuuren, Kok, Girod, Lucas, & de Vries**
 25936 **(2012), compared with a number of scenario archetype studies and characterizations.**

van Vuuren et al. (2012)	Global scenario group	(Hunt et al., 2012)	(Kok et al., 2013)	(Rothman, 2008)	Philosophy ¹	Motto ¹
Economic optimism	Market forces	Market forces	Global markets	Market forces	Market optimism	Don't worry, be happy
Reformed markets	Policy reform	Policy reform	Global sustainability	Policy reform	Policy stewardship	Equity and growth
Global sustainable development	New sustainability paradigm	New sustainability paradigm	-	New sustainability paradigm	Sustainability as global social evolution	Human solidarity
Regional sustainability	Eco-communalism	Eco-communalism	Regional sustainability	Eco-communalism	Pastoral romance	Small is beautiful
Regional competition	Fortress world	Fortress world	Continental barriers	Fortress world	Social chaos	Order through strong leaders
-	Breakdown	Breakdown	-	Breakdown	Existential gloom	The end is coming
Business-as-usual	Muddling through	-	-	Muddling through	No grand philosophers	-

25937 ¹ Taken from (Rothman, 2008).

25938 Comparing the exploratory scenarios for Europe and Central Asia with global scenario archetypes reveals that
 25939 the *global sustainable development* and *regional competition* archetypes tend to be present in almost all of the
 25940 scenario sets (**Table 5.2**). This pair of contrasting scenarios (“global-good” and “regional-bad”) seem to translate
 25941 well to a variety of different scenario settings. The *economic optimism* archetype is also present in most scenario
 25942 sets. It is absent only from the CLIMSAVE scenarios, which were constructed at the height of the 2008 global
 25943 economic crisis.

25944 A small proportion of scenarios for Europe and Central Asia do not match the global archetypes. Most notably
 25945 SSP4 (and the similar CLIMSAVE *riders on the storm*; Harrison et al. (2015)) do not have an equivalent in the
 25946 scenario families from van Vuuren et al. (2012). These scenarios depict a future with a fundamental increase in
 25947 inequality between and within countries with a strong green elite, which is difficult to match to earlier scenario
 25948 review efforts. This type of scenario might increase in importance with the growing use of the IPCC-related *shared*
 25949 *socioeconomic pathways* (SSPs) (O'Neill et al., 2015), in environmental assessments.

25950 **Table 5.2: The van Vuuren et al. (2012) scenario archetypes and their equivalents in Europe and**
 25951 **Central Asia scenario sets.**
 25952

	Global scenario archetypes					Not matching
	Economic optimism	Global sustainable development	Regional sustainability	Regional competition	Business-as-usual	
ALARM	Growth applied strategy (GRAS)	Sustainable European development goal (SEDG)	-	-	Business as might be usual (BAMBU)	

CLIMSAVE	-	We are the world	-	Icarus; should I stay or should I go	-	Riders on the storm
EURuralis	Global economy	Global cooperation	Regional communities	Continental markets	-	
Hanspach et al. (2014)	Prosperity through growth	Balance brings beauty	-	Our land, their wealth	-	Missed opportunity
MA-Portugal	Global orchestration	Techno garden	Adapting mosaic	Order from strength	-	
SCENES	Economy First	Policy rules	Sustainability eventually	Fortress Europe	-	
SRES-Europe	A1B, A1FI	B1	B2	A2	-	
SSPs-Europe and Central Asia	SSP5	SSP1	-	SSP3	SSP2	SSP4
UK NEA	World markets	Nature @ work	Local stewardship; Green and pleasant land	National security	Go with the flow	

25953

25954 **END OF BOX 5.3**

25955

25956 **5.2.3 Description of plausible futures for Europe and Central Asia**

25957 This section describes projected future changes in the different indirect and direct drivers represented
 25958 within the exploratory scenarios for Europe and Central Asia for each scenario archetype. These are
 25959 summarized in **Table 5.3**. Representation of different dimensions of value within the scenario
 25960 archetypes are summarized in **Figure 5.7** and described under each of the descriptions of the scenario
 25961 archetypes.

25962 **Table 5.3: Trends in indirect and direct drivers in selected scenarios for each of the Europe and**
 25963 **Central Asia scenario archetypes. Arrows in the table are based on expert interpretation of the**
 25964 **magnitude of trends in given drivers: single arrow = moderate change, double arrow = strong change.**
 25965 **Rows with grey background summarize general trends across all scenarios found within the**
 25966 **archetypes. Color-coding of arrows is based on expert interpretation of the impact of the trend on**
 25967 **nature or its contributions to people: blue = favourable, orange = unfavourable, grey = neutral.**
 25968 **Trends in demographic (population), economic (GDP and globalization) and land use change**
 25969 **(landscape homogeneity/deforestation) drivers were not interpreted in terms of impact (white).**

25970 References: ¹Archetypes: (IPBES, 2016c; van Vuuren et al., 2012), ²(Millennium Ecosystem Assessment, 2005),
 25971 ³(Reder et al., 2013), ⁴OpenNESS project: (Hauck et al., 2017), ⁵IMPRESSIONS project: (Kok & Pedde, 2016),
 25972 ⁶(Stokal et al., 2014), ⁷UK NEA: (Haines-Young et al., 2011), ⁸(Milestad et al., 2014), ⁹SCENES: (Kok et al., 2011),
 25973 ¹⁰(O'Neill et al., 2015).

Driver		DEM	ECO		CUL	TEC	INS		CLI	LUC	NRE	POL	INV
Trend		Population	GDP	Globalisation	Sustainable consumption	Technology	Efficiency of governance	Envi. management proactivity	Temperature/ radiative forcing	Landscape homogeneity/ deforestation	Natural-resource exploitation	Pollution	Invasions
Archetype/ scenario	Region												
Business-as-usual ¹	ECA	↑	↑	↑	↓	↑	↓	↑↓	↑	↑	↑	↑	↑
SSP2 ¹⁰	ECA	↑	↑	↑	↓	↑	↓	↓		⇒	↑	↑	
Go with the flow ⁷	EU	↑↑	↑	↑		⇒			↑/↑↑	↑↑			↑
Economic optimism ¹	ECA	↑↑	↑↑	↑	↓	↑↑	⇒	↓	↑↑	↑	↑↑	↑	↑
Global orchestration ²	Global	↑↑	↑↑	↑	↓	⇒		↓	↑↑	⇒		↑	↑
Economy first ³	EU	⇒	↑↑	↑		↑↑	↓	↓	↑/↑↑	⇒	↑↑	↑	
Wealth-being ⁴	EU	↑↑	↑↑	↑	↑↓	↑↑			↑↑	↑	↑↑		
CA SSP 5 Fossil-fuelled development ⁵	Central Asia	↑	↑	↑		↑	↑				⇒		
Global orchestration ⁶	Black Sea region	↑↑	↑↑	↑	↓	↑		↓		⇒	↑↑	↑	
World markets ⁷	UK	↑↑	↑	⇒	↓	↑			↑/↑↑	↑	↑↑		↑
1A ⁸	Sweden	↑↑	⇒	↑		↑				↑			
Regional competition ¹	ECA	⇒	⇒	↓	⇒	↓	↑↓	↓	↑	↑	↑	↑	↑
Order from strength ²	Global	⇒	⇒	↓	⇒	↓		↓	↑	↑		↑↑	↑
Fortress Europe ⁹	EU	⇒	⇒	↓↓		↓	↑↓	↓			↑	↑	
EU SSP3 ⁵	EU	↓↓	⇒	↓↓	⇒	↓	↑↓	↓	↑↑				
CA SSP3 Regional rivalry ⁵	Central Asia	↓	↓	↓↓		↓	↓	↑↓			↑↑		

25974

Driver		DEM	ECO		CUL	TEC	INS		CLI	LUC	NRE	POL	INV
Trend		Population	GDP	Globalisation	Sustainable consumption	Technology	Efficiency of governance	Envi. management proactivity	Temperature/ radiative forcing	Landscape homogeneity/ deforestation	Natural-resource exploitation	Pollution	Invasions
Archetype/ scenario	Region												
National security ⁷	UK	↑	⇒	↓	⇒	↑			↑ / ↑↑	↑↑	↑		⇒
2A ⁸	Sweden	↑↑	⇒	↓		↓				↓			
Regional sustainability ¹	ECA	↑	↑	↓	⇒	↑	↑	↑	↑	↓	↓	⇒	↓
Adapting mosaic ²	Global	↑	↑	↓	⇒	⇒		↑	↑↑	⇒		⇒	↓
Sustainability eventually ⁹	EU	⇒	⇒	↓		⇒	↑↑	↑			↓	↓	
Rural revival ⁴	EU	↓	↓	⇒	↑↑	↓		↑	↑	⇒	↓		
Adapting mosaic ⁶	Black Sea region	↑	↑	↓	⇒	⇒		↑		⇒		⇒	
Green and pleasant land ⁷	UK	⇒	↑	⇒	⇒	↑↑			↑ / ↑↑	↓	↓		⇒
Local stewardship ⁷	UK	⇒	⇒	↓	⇒	↑↑			↑ / ↑↑	↓	⇒		↓
2B ⁸	Sweden	↑	↑	↓		↓				↓			
Global sustainable development ¹	ECA	⇒	↑	↑↑	↑	↑↑	↑	↑	↑	↑	↓	↓	↓
Techno garden ²	Global	↑	↑	↑	⇒	↑↑		↑	↑	⇒		↓	⇒
Policy rules ⁹	EU	⇒	⇒	⇒		⇒	↓	↑			↑	↓	
United we stand ⁴	EU	↑	↑	⇒	↓	↑↑		↓	↑	↑	↑↑		
CA SSP1 Sustainability ⁵	Central Asia	↑	↑↑	↑↑		↑↑	↑↑	↑			↓		
Nature @ work ⁷	UK	↑	↑↑	↑	↑	↑↑			↑ / ↑↑		↓		↓
1B ⁸	Sweden	↑	↑	↑		↑				↑			
Inequality ¹	ECA	↓	↑	↑	⇒	⇒	↓	↓	↑		↑		
EU SSP4 ⁵	EU	↓	↑	↑	⇒	⇒	↓	⇒	↑				
CA SSP4 A game of elites ⁵	Central Asia	⇒	⇒	↑		⇒	↓	↓			↑		

25975

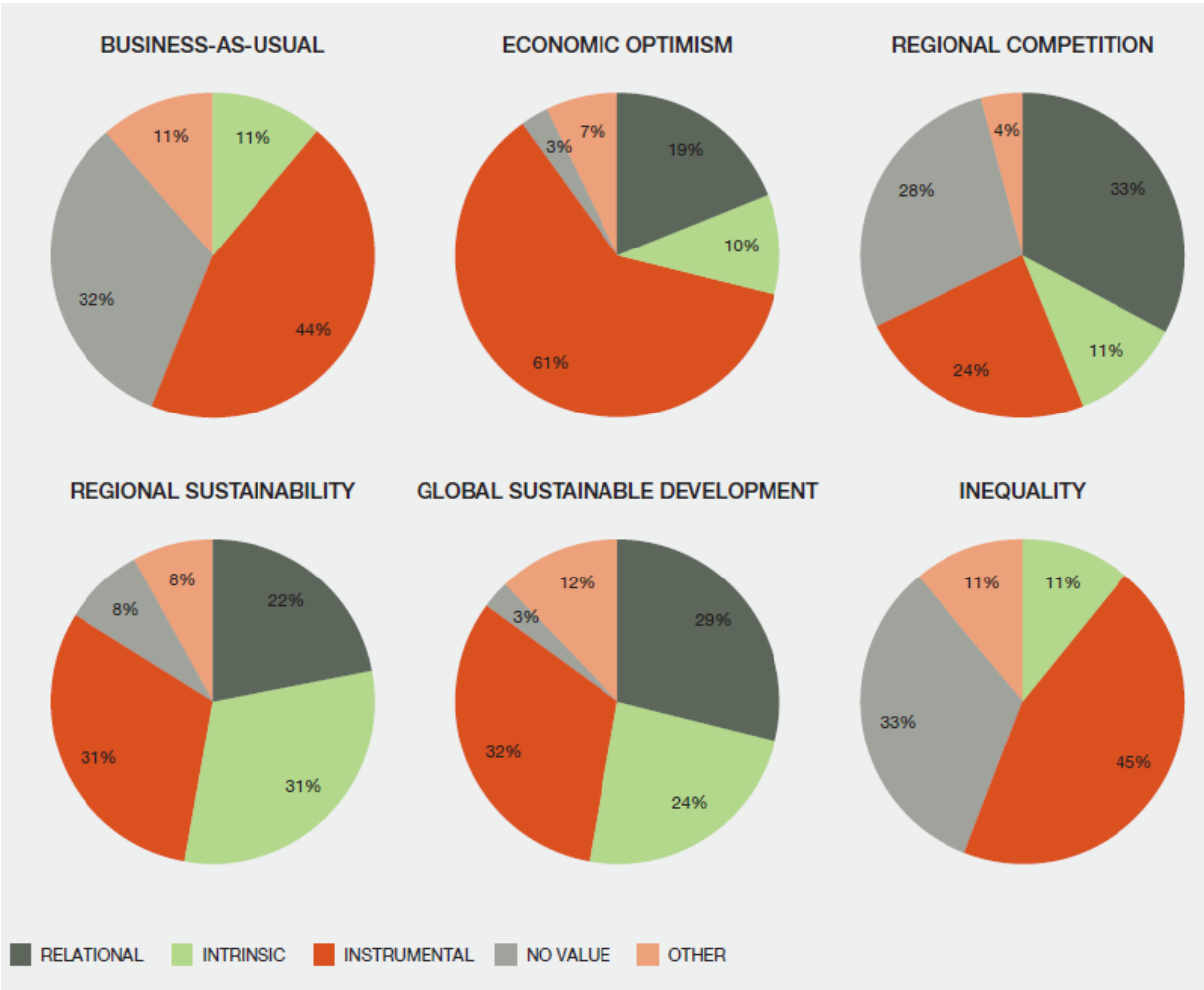


Figure 5.7: Representation of different dimensions of value within the reviewed scenario studies for Europe and Central Asia summarized by scenario archetype. Categorization undertaken by the author team. No value = no values were found (explicitly or implicitly) in the scenario studies.

5.2.3.1 Business-as-usual

Overview: *Business-as-usual* assumes that the future will be characterized by a continuation of past and current social, economic and technological trends. Sometimes referred to as a reference scenario, this archetype can also be considered as a less extreme variant of the *economic optimism* archetype. Although there is, on average, moderate population and economic growth under this archetype, development and income growth are uneven across countries. At the same time, *inequality* and societal stratification persist. International markets and institutions are mostly stable, but function imperfectly. Technological development is moderate, but without fundamental innovations, and the use of fossil fuels does not substantially decrease (O'Neill et al., 2015).

Indirect drivers: Most scenarios under the *business-as-usual* archetype represent reference scenarios that assume current trends in population, GDP, consumption and management of natural resources (Popp et al., 2010; Stehfest et al., 2009; Wirseniens et al., 2010). Only three scenarios are associated with storylines that explain future developments: “BAMBU” from the ALARM project (e.g. Stocker et al., 2012), *go with the flow* from the UK NEA (Haines-Young et al., 2011) and SSP2, also known as “middle of the road” (e.g. O'Neill et al., 2015; Obersteiner et al., 2016). These scenarios generally

25997 assume moderate population and economic growth, and a continued expansion of global free-market
 25998 enterprises (Haines-Young & Potschin, 2010; O'Neill et al., 2015; Stocker et al., 2012), with some
 25999 national differences, e.g. a relatively high increase in the UK population (Haines-Young et al., 2011)
 26000 (**Table 5.3**). While environmental improvement is seen as important, society and industry are reluctant
 26001 to adopt many global or national environmental policies that would lead to substantial change (Haines-
 26002 Young & Potschin, 2010).

26003 *Direct drivers:* The *business-as-usual* archetype assumes moderate to high intensity of climate change
 26004 (Dullinger et al., 2015; Fronzek et al., 2012; Hickler et al., 2012). At the scale Western Europe and parts
 26005 of Central Europe, increases in woodland and reductions in grassland are assumed (Mitchley et al.,
 26006 2006; Partidário et al., 2009; Sheate et al., 2008). Land homogenization trends differ across Western
 26007 and Central Europe (e.g. substantial countryside homogenization in the UK; Haines-Young & Potschin,
 26008 2010) and limited concentration of agricultural land in Croatia (Pukšec et al., 2014). Moderate to high
 26009 levels of pest outbreaks and alien species invasions are expected (European Union – Chytrý et al.
 26010 (2012); UK – Haines-Young & Potschin (2010); Austria – Seidl et al. (2008)).

26011 *Values:* This scenario archetype is strongly focused on instrumental values (44%), although no value
 26012 (32%) is also associated with many of its dimensions (**Figure 5.7**). It typically lacks any
 26013 acknowledgement of relational or intrinsic values implying a lack of long-term focus on conserving
 26014 nature. For example, Spangenberg et al. (2012) identified that an extension of current trends in
 26015 European Union policies may slow down the loss of biodiversity in many cases and in most biomes, but
 26016 it will not be capable of halting or reversing the loss.

26017

26018 5.2.3.2 *Economic optimism*

26019 *Overview:* Global developments steered by economic growth result in a strong dominance of
 26020 international markets with a small degree of regulation. Population growth varies from low (assuming
 26021 a strong drop in fertility levels) to stable and high depending on the specific scenario. Technological
 26022 development is rapid and there is a partial convergence of income levels across the world.
 26023 Environmental problems are only dealt with when solutions are of economic interest. A more extreme
 26024 variant of this archetype is the SSP5 type of fossil fuel dominated markets with little environmental
 26025 concern, but with highly equal and healthy societies. In terms of biodiversity and nature's contributions
 26026 to people, this archetype can range from devastating (environmental destruction) to positive
 26027 (economically viable nature-based solutions). Yet, in all cases, a reactive attitude to environmental
 26028 management prevails.

26029 *Indirect drivers:* Several scenarios corresponding to the *economic optimism* archetype describe a future
 26030 with low population growth in Europe and Central Asia according to SRES A1 (European Union – Stocker
 26031 et al., 2014; Central Europe – Fischer et al., 2011; Germany – Dietrich et al., 2012; Hattermann et al.,
 26032 2015; Koch et al., 2011; Steidl et al., 2015), which is concentrated in cities and leads to substantial
 26033 urban sprawl (Fazeni & Steinmüller, 2011; Kok et al., 2011; Louca et al., 2015; Reder et al., 2013).
 26034 However, several national scenarios outline a contrasting trend, assuming high population growth, for
 26035 example in Sweden (Milestad et al., 2014), the UK (*world markets*; Haines-Young et al., 2011) and
 26036 Portugal (*global orchestration*; Pereira et al., 2009) (**Table 5.3**).

26037 This archetype is characterized by intensive economic development with the highest GDP growth of all
 26038 archetypes (SSP5/SRES A1; Millennium Ecosystem Assessment, 2005; Reder et al., 2013) across the
 26039 majority of countries in Europe and Central Asia (Garrote et al., 2016; Koch et al., 2011) (**Table 5.3**).
 26040 The level of international cooperation is high (global orchestration - Millennium Ecosystem Assessment
 26041 (2005); Reder et al. (2013)), however, this may involve only the privileged few (economy first -

Okruszko et al. (2011); Reder et al. (2013)). The scenarios assume a reactive attitude towards environmental management (economy first - Kok et al. (2011); Reder et al. (2013)). Lifestyles are resource-intensive, with high meat and material consumption (*world markets, global orchestration, EU SSP5*) (Haines-Young et al., 2011; Kok & Pedde, 2016; Millennium Ecosystem Assessment, 2005; Stokral et al., 2014). The globalization of lifestyles also influences diets. For example, the *world markets* scenario for the UK assumes increasing consumption of processed meals and fast food (Haines-Young et al., 2011). In Central Asia, the respective scenario assumes globalization of lifestyles with consumption patterns mirroring those in other parts of the world (SSP5; Kok & Pedde, 2016). Technological development is rapid (SSP5/SRES A1; Koch et al., 2011; Reder et al., 2013; Stocker et al., 2014), with an emphasis on efficiency, including increasing agricultural productivity (*global orchestration*; Seitzinger et al., 2010; Stokral et al., 2014; CA SSP5 – Kok & Pedde, 2016). For example, the respective scenario for the UK assumes investments in multiple types of technologies, including IT, transport, military, pharmaceutical and genetic modification technologies (*world markets*; Haines-Young et al., 2011).

Direct drivers: In terms of climate change, Europe and Central Asia is affected by the most severe warming (SRES A1B/A1FI) compared to other archetypes (Okruszko et al., 2011; Reder et al., 2013) (**Table 5.3**). Surface and groundwater availability is expected to decrease in many countries due to changing precipitation patterns and higher evapotranspiration (Germany – Barthel et al. (2012); Dietrich et al. (2012); Hattermann et al. (2015); Mediterranean – Garrote et al. (2016)), with subsequent implications for agricultural irrigation (Germany – Steidl et al. (2015); Mediterranean – Garrote et al. (2016)). At the same time, the scenarios assume a substantial increase in natural resource and water consumption (around 30% in the European Union – Flörke et al. (2012); Kok et al. (2011); Okruszko et al. (2011)) and intensive utilization of biofuels (Milestad et al., 2014; van Wijnen et al., 2015). Accordingly, trends in fertilizer use and nutrient input are increasing (*global orchestration, economy first*) (Millennium Ecosystem Assessment, 2005; Reder et al., 2013; Stokral et al., 2014), with subsequent implications for environmental degradation and pollution (Kok et al., 2011; Reder et al., 2013).

Values: As with *business-as-usual*, this scenario archetype consists of predominantly instrumental values (66%) and individualistic perspectives (**Figure 5.7**). Management of nature and its contributions to people is based on an economic “internalization of externalities” (Reed et al., 2013) and single-value approaches, which are unlikely to offer effective sustainable solutions to the progressive environmental degradation (Jacobs et al., 2016).

5.2.3.3 Regional competition

Overview: Regional competition assumes a world regionalized according to economic developments. The market mechanism fails, leading to a growing gap between rich and poor. This, in turn, results in increasing problems with crime, violence and terrorism, which results in significant trade and other barriers. The effects on the environment and biodiversity are mixed. Overall, there is a tendency towards increased security, which can be either positive (by protecting biodiversity) or negative (by intensifying agricultural production).

Indirect drivers: The *regional competition* archetype assumes fragmentation and disintegration within Europe and Central Asia, leading to weak cooperation between countries, and regionalism (*fortress Europe, EU/CA-SSP3*) (Kok et al., 2011, 2013; Kok & Pedde, 2016). Population growth projections are variable at the national level, ranging from low (*order from strength* scenario in Portugal – Pereira et al. (2009) to high (Switzerland – Neteler et al. (2013); Lithuania – Ozolincius et al. (2014)), and with

contradictory trends projected for the whole of the European Union (SRES A2) (Eliseev & Mokhov, 2011; Gao & Giorgi, 2008; Kok et al., 2011; Millennium Ecosystem Assessment, 2005; Milestad et al., 2014; Neteler et al., 2013; Seitzinger et al., 2010). By contrast, economic development is assumed to be slow in almost all scenarios (SRES A2 Eliseev & Mokhov (2011); van den Hurk et al. (2005); van Slobbe et al. (2016)) (**Table 5.3**).

The archetype is characterized by high *inequality*, declining social cohesion and decreases in human capital (EU/CA-SSP3) (Kok et al., 2011; Kok & Pedde, 2016). The emphasis on self-sufficiency is high (Thaler et al., 2015), and the predominant approach to environmental issues is reactive (*fortress Europe, order-from-strength* scenarios) (Kok et al., 2011; Millennium Ecosystem Assessment, 2005). Barriers in collaboration lead to slow technological development (SRES A2/SSP3; Latkovska et al., 2012; Reidsma et al., 2006; van Meijl et al., 2006), even described as strongly decreasing or failing (*fortress Europe, EU SSP3*) (Kok et al., 2011; Kok & Pedde, 2016) (**Table 5.3**). In Central Asia, this archetype suggests potentially serious consequences for societal functioning (CA-SSP3) (Kok & Pedde, 2016).

Direct drivers: Climate change is expected to be relatively severe (SRES A2; Bourdôt et al., 2012; Eliseev & Mokhov, 2011; Kelly et al., 2014; Latkovska et al., 2012; Neteler et al., 2013). The pattern of land use change largely differs among countries, with mixed trends in the extent of agricultural land (Eliseev & Mokhov, 2011; Pereira et al., 2009), land use intensification (Haines-Young et al., 2011; Seitzinger et al., 2010) and land homogenization (Haines-Young et al., 2011; Milestad et al., 2014). Conflicts regarding natural resources are expected to increase (*order from strength*; Millennium Ecosystem Assessment, 2005), with substantial use of local energy resources (*national security* - Haines-Young et al., 2011). Similarly, projections of the likelihood of biotic invasions vary from high (Kelly et al., 2014; Millennium Ecosystem Assessment, 2005; Ozolincius et al., 2014) to low (Haines-Young et al., 2011) (**Table 5.3**).

Values: This scenario archetype is strongly focused on relational (33%) and instrumental values (24%), but also includes a no value (28%) perspective (**Figure 5.7**). Although scenarios under this archetype include relational values (good quality of life indicators), they assume that regions will focus more on self-reliance, national sovereignty and regional identity. This leads to diversity in values, but also to tensions among regions or cultures (van Vuuren et al., 2012). In such futures, it may be difficult to protect biodiversity because of a combination of strong control of institutions (generally top-down) and lack of synergy between different levels of governance. Approaches to biodiversity protection are local (if any) and further constrained by a lack of concern for global environmental problems (Kok et al., 2013).

5.2.3.4 Regional sustainability

Overview: Regional sustainability assumes a regionalized world based on an increased concern for environmental and social sustainability. International institutions decline in importance, with a shift toward local and regional decision-making. Decision-making is increasingly influenced by environmentally aware citizens, with a trend toward local self-reliance and stronger communities that focus on welfare, equality, and environmental protection through local solutions. A proactive attitude to environmental management prevails, which is beneficial for biodiversity and nature's contributions to people. The strong regional character and poor international collaboration, however, are causing problems with technology transfers, generate a relatively high demand for agricultural land, and obstruct coordination to solve global issues such as climate change, which all put pressure on the environment. Two sub-types can be discerned:

26131 a) Focus on local governance: Fundamental change is initiated by a broadly supported and
 26132 bottom-up enforced paradigm shift, often accompanied by a dematerialization process and a
 26133 “back to nature” attitude.

26134 b) Focus on collaborative solutions to local issues: Fundamental change is initially fostered by
 26135 higher-level institutions, recognizing the value of local action in a slowly regionalizing world.

26136 *Indirect drivers:* The *regional sustainability* scenario archetype is characterized by empowerment of
 26137 local decision-making and bottom-up governance both at the national (e.g. *local stewardship* - Haines-
 26138 Young et al. (2011)) and the European Union level (*sustainability eventually* - Kok et al. (2011)). Most
 26139 scenarios corresponding to this archetype assume medium population growth (SRES B2) in both the
 26140 European Union (Reidsma et al., 2006; van Meijl et al., 2006) and individual European Union countries
 26141 (Germany – Dietrich, Steidl, & Pavlik (2012); Latvia – Latkovska et al. (2012)). In contrast, in some
 26142 scenarios population growth is assumed to be low (Germany and the UK – Haines-Young et al. (2011);
 26143 Koch et al. (2011)), or even to decrease (European Union: *rural revival* – Hauck et al. (2017)) (**Table**
 26144 **5.3**).

26145 The estimates of potential future economic development at the scale of Western Europe and parts of
 26146 Central Europe under *regional sustainability* range between slow and medium (SRES B2 – Kok et al.
 26147 (2011); Strokal et al. (2014)). Several scenarios assume uneven levels of economic development among
 26148 countries (e.g. *adapting mosaic* - Millennium Ecosystem Assessment (2005), Seitzinger et al. (2010)).
 26149 Furthermore, contrasting projections are reported for several countries (e.g. Germany – Dietrich et al.
 26150 (2012); Koch et al. (2011); Cyprus – Gao & Giorgi (2008); Louca et al. (2015)). The archetype is
 26151 characterized by consumption patterns oriented towards local food and products, as well as food self-
 26152 sufficiency (*local stewardship* – Haines-Young et al. (2011); Austria – Fazeni & Steinmüller (2011);
 26153 Sweden – Milestad et al. (2014)) and organic farming (Austria – Thaler et al. (2015)). Meat consumption
 26154 is medium both in global and national scenarios, with an emphasis on different regional and local
 26155 products, fresh food, meat and fish (*local stewardship* – Haines-Young et al. (2011); *adapting mosaic* –
 26156 Millennium Ecosystem Assessment, 2005). As with economic development, technological
 26157 development is assumed to be medium and uneven across the European Union (SRES B2 - Latkovska
 26158 et al. (2012); Reidsma et al. (2006); van Meijl et al. (2006)), ranging from energy-related technologies
 26159 (Germany – Koch et al. (2011)) through clean and resource-efficient technologies (Austria – Thaler et
 26160 al. (2015); Cyprus – Louca et al. (2015); Black Sea region – Strokal et al. (2014)) to a highly diversified
 26161 technological portfolio developed at a moderate pace (Germany – Dietrich et al. (2012); Latvia –
 26162 Latkovska et al. (2012)) (**Table 5.3**).

26163 In general, a strong focus on sustainability is assumed, namely in terms of the development of
 26164 sustainable technologies and increasing energy efficiency (*local stewardship* – Haines-Young et al.
 26165 (2011)), higher efficiency in fertilizer use (*adapting mosaic* – Strokal et al. (2014)) and water saving
 26166 technologies (*sustainability eventually* – Kok et al. (2011)), as well as higher standards for
 26167 environmental protection and strong conservation policies (Bolliger et al., 2007; Koch et al., 2011).

26168 *Direct drivers:* Climate change assumptions range from medium (Mediterranean – Gao & Giorgi (2008);
 26169 Ireland – Kelly et al. (2014); Latvia – Latkovska et al. (2012)) to high (Germany – Dietrich et al. (2012);
 26170 Koch et al. (2011)), particularly in terms of temperature increases across the European Union
 26171 (*sustainability eventually* – Okruszko et al. (2011)). The regionalized character of this archetype results
 26172 in diverse, heterogeneous patterns of land use and land cover change both within individual countries
 26173 (particularly northern Europe Union – Haines-Young et al. (2011); Milestad et al. (2014)) and across
 26174 Western and Central Europe (increase in non-intensive open land in Switzerland – Bolliger et al. (2007);
 26175 increase in artificial surfaces in Cyprus – Louca et al. (2015)). Similarly, projected trends in natural
 26176 resource exploitation are mixed. For example, although some scenarios assume decreases in total

water withdrawals at the European Union level (Okrusko et al., 2011), scenarios for Germany (Dietrich et al., 2012) project increasing water consumption and decreasing water availability. In terms of pollution, the emphasis on sustainability leads to stable or decreasing fertilizer use (Nol et al., 2012; Strokal et al., 2014), low increases in O₃ emissions across the European Union (Jiménez-Guerrero et al., 2013) and a substantial decline in nutrient emissions to the Black Sea and the Mediterranean (Ludwig et al., 2010). The regionalized character of the archetype leads to low dispersion of invasive alien species and reductions in invasions due to stricter border control (*local stewardship, adapting mosaic* – Haines-Young et al. (2011); Millennium Ecosystem Assessment (2005)) (**Table 5.3**).

Values: The *regional sustainability* archetype is centred on an inclusive and balanced distribution of intrinsic (31%), instrumental (31%) and relational (22%) values (**Figure 5.7**). The inclusiveness and balance among different types of values is favourable for sustainability efforts because it leads to regional solutions for environmental and social problems, often through combining drastic lifestyle changes with decentralization of governance (van Vuuren et al., 2012). These diverse values could have positive effects on biodiversity conservation through a focus on management styles such as low-impact farming and energy-efficient lifestyles based on local low-tech development (Kok et al., 2013).

5.2.3.5 Global sustainable development

Overview: *Global sustainable development* assumes a globalized world with an increasingly proactive attitude of policymakers and the public at large towards environmental issues and a high level of regulation. Important aspects on the road to sustainability are technological change, strong multi-level governance, behavioural change through education, and a relatively healthy economy. All variations of this archetype are beneficial for biodiversity, either through behavioural change, top-down “green” policies or through green technology development. In all cases, this is reinforced by a proactive attitude to dealing with environmental problems. Sub-types include:

- a) Focus on technological development and technology transfer: Solutions are mainly found in (green) technological change in all sectors, including for example engineered ecosystems to deliver nature’s contributions to people.
- b) Focus on strong governments: Strong, mostly top-down, governance structures are effective in enforcing a more sustainable world, e.g. through taxes, pricing mechanisms, and strict regulations.
- c) Focus on paradigm shift: An increased collaboration of private and public partners across scales leads to strong behavioural change towards environmental protection and sustainable development.

Indirect drivers: The *global sustainable development* archetype is characterized by a high degree of international cooperation (Millennium Ecosystem Assessment, 2005) and top-down governance (Kok et al., 2011). The scenarios corresponding to this archetype assume low to medium population growth across the European Union (SRES B1 - Ozolincius et al. (2014); Reidsma et al. (2006); van Meijl et al. (2006); van Slobbe et al. (2016)), but moderate population growth in Central Asia (SSP1, Kok & Pedde, 2016). The assumptions regarding future economic development in the European Union under this archetype are highly variable, ranging from rapid (SSP1 in Central Asia – Kok & Pedde (2016); *nature @ work* in the UK – Haines-Young et al. (2011); Hungary – Gálos et al. (2011)) through to medium (EU SSP1 – Kok & Pedde (2016); Central Europe – Uthes et al. (2009) ; Sweden – Milestad et al. (2014)) and slow (*policy rules* scenario for Europe – Kok et al. (2011); Cyprus – Louca et al. (2015)) (**Table 5.3**).

26220 In both Europe and Central Asia, the scenarios envision strong increases in human and social capital,
 26221 and high levels of social respect and cohesion (Kok et al., 2013; Kok & Pedde, 2016). In Central Asia,
 26222 *global sustainable development* is the only archetype under which the cooperation between countries
 26223 in the region increases and transboundary water governance is implemented (CA-SSP1; Kok & Pedde,
 26224 2016).

26225 In terms of cultural trends, the scenarios assume low to medium material consumption for the
 26226 European Union (Kok & Pedde, 2016; Millennium Ecosystem Assessment, 2005) with a proactive
 26227 approach to environmental management (Kok et al., 2011; Millennium Ecosystem Assessment, 2005).
 26228 While the UK *nature @ work* scenario (Haines-Young et al., 2011) assumes higher consumption of local
 26229 products, a generally similar scenario for Sweden assumes lower consumption trends (Milestad et al.,
 26230 2014). Technological development is rapid, focusing on green and resource-efficient technologies
 26231 (SRES B1/SSP1, *techno garden* (Kok et al., 2011; Kok & Pedde, 2016; Millennium Ecosystem
 26232 Assessment, 2005)), biotechnology and sustainable technologies (Haines-Young et al., 2011; Kok et al.,
 26233 2011) (**Table 5.3**).

26234 *Direct drivers*: Climate change is assumed to predominantly follow the SRES B1 pathway with the
 26235 lowest increase in surface temperature compared to other scenario archetypes (Fischer et al., 2011;
 26236 Ozolincius et al., 2014; Scholten et al., 2014). In terms of water regime, the discharge from major rivers
 26237 is assumed to decrease, for example in the case of the Black Sea and the Mediterranean Sea (Garrote
 26238 et al., 2016; Ludwig et al., 2010). Multiple studies assume medium dispersion of invasive species both
 26239 at the European Union level (Chytrý et al., 2012) and in individual countries (Central Europe – Fischer
 26240 et al., 2011; the Baltic countries – Ozolincius et al., 2014). In contrast, the UK *nature @ work* scenario
 26241 assumes low dispersion of invasive species due to extensive national programmes (Haines-Young et
 26242 al., 2011) (**Table 5.3**).

26243 *Values*: As with *regional sustainability*, *global sustainable development* is centred on instrumental
 26244 (32%), intrinsic (24%) and relational (29%) values (**Figure 5.7**). Again, due to the inclusiveness and
 26245 balance among different types of values, this archetype favours sustainability efforts. This scenario
 26246 explores visionary solutions to the sustainability challenge at the global scale, including new socio-
 26247 economic arrangements and fundamental changes in values (Kubiszewski et al., 2017).

26248

26249 5.2.3.6 Inequality

26250 *Overview*: *Inequality* assumes increasing economic, political and social inequalities and fragmentation
 26251 both across and within countries. This future is characterized by power becoming more concentrated
 26252 in a relatively small political and business elite across the globe. Economic growth is moderate in
 26253 industrialized and middle-income countries, while low income countries lag behind. Technology
 26254 develops unevenly. Environmental policies focus on local issues and are limited to higher-income areas
 26255 (O'Neill et al., 2015). The European Union increases its commitment to find innovative solutions to the
 26256 depletion of natural resources and climate change, which initiates a shift towards a high-tech green
 26257 Europe. However, there are increasing disparities in economic opportunity, leading to substantial
 26258 proportions of populations having a low level of development. The European Union becomes an
 26259 important player in a world full of tensions. In Central Asia, the concentration of wealth and power in
 26260 a narrow class of elites grows, while the standard of life of the majority gradually deteriorates. Political
 26261 regimes in the region are increasingly authoritarian and repressive, with growing incidence of social
 26262 unrest, conflicts and ethnic clashes on the one hand, and outmigration and resignation on the other.
 26263 Environmental issues are addressed only to a limited extent, particularly in relation to water and
 26264 energy supplies, so as not to threaten the position of the elites (Kok & Pedde, 2016).

Only four scenarios in the review for Europe and Central Asia fall into the *inequality* scenario archetype. These are the Europe and Central Asian SSP4 scenarios (Kok & Pedde, 2016) from the IMPRESSIONS project, the Romanian *missed opportunity* scenario (Hanspach et al., 2014), and the European *riders on the storm* scenario (Kok et al., 2013) from the CLIMSAVE project; the latter being applied in a number of studies (e.g. Brown et al., 2015; Dunford et al., 2015; Harrison et al., 2015; Mokrech et al., 2014; Wimmer et al., 2015).

Indirect drivers: Scenarios under this archetype show contrasting trends in population for Europe and Central Asia with population increasing in Central Asia until the middle of the century when it stabilizes, but decreasing in Western and Central Europe (EU/CA-SSP4) (Kok & Pedde, 2016). Similar differences are seen for economic growth, which remains stable in Central Asia compared to high economic development in Europe. Although the efforts of the elite mostly aim at increasing (economic) power, there is increasing interest in addressing certain environmental issues, including basic rules of conduct regarding water management, infrastructural projects (water, road, rail), and energy production, which further drives technological development (EU/CA-SSP4) (Kok et al., 2013; Kok & Pedde, 2016) (**Table 5.3**).

In Central Asia the national governments gradually increase their own power by concentrating wealth and power in the upper class (CA-SSP4) (Kok & Pedde, 2016). Anti-elite movements gradually become more widespread resulting in social unrest, but the elite ensure the masses receive a minimum of services to decrease the chance of revolts.

Direct drivers: This archetype is associated with an intermediate level of climate change in Europe and Central Asia (RCP4.5, which has temperature increases of between 2 and 3°C). Land use in Europe sees a steadily declining agricultural area and an increase in forests and biofuels. Alternatively, in Central Asia there is a gradual move towards large collective farms controlled by elites. Little information is provided on pollution and invasive alien species, but these issues are expected to be strongly regulated when advantageous to the elites (Kok & Pedde, 2016) (**Table 5.3**).

Values: As in *business-as-usual*, this scenario archetype is strongly focused on instrumental values (45%), but also with a no value (33%) perspective (**Figure 5.7**). In such a future, it may be difficult to conserve biodiversity because of a lack of acknowledgement of the diverse values of nature resulting in conservation efforts focusing on nature's contributions to people (i.e. anthropocentric instrumental values). Additionally, the increasing trend of social inequalities might create social conflict amongst different stakeholders around environmental issues (van Egmond & de Vries, 2011).

5.2.4 Linking plausible futures for Europe and Central Asia to policy goals and targets

Several of the Sustainable Development Goals and Aichi Biodiversity Targets refer to trends in indirect or direct drivers. These include those related to climate change, pollution, invasive alien species, sustainable management of ecosystems, and sustainable consumption and production. Here, we relate the six plausible futures for Europe and Central Asia, as described in Section 5.2.3, to the Sustainable Development Goals and Aichi Biodiversity Targets and discuss how they are likely to affect their realization, as preconditions for sustaining nature and its contributions to people. Our interpretation is based on the changes in indirect and direct drivers across scenarios within each archetype (as summarized in **Table 5.3**).

Climate change: Combating climate change (Goal 13 of the Sustainable Development Goals) is not completely achieved in any scenario archetype as they all assume some level of global warming.

However, the degree of climate change varies considerably among archetypes, with the *global sustainable development* archetype moving the least away from Goal 13.

Pollution and invasive alien species: Decreasing pollution to non-detrimental levels (Target 8 of the Aichi Biodiversity Targets) and controlling invasive alien species (Target 9, Goal 15) are least likely to be achieved in Europe and Central Asia under the *business-as-usual*, *economic optimism* and *regional competition* scenario archetypes. Pollution-related targets could potentially be easier to achieve under the *global sustainable development* archetype, while decreasing biological invasions could be reached under the *regional sustainability* archetype.

Habitat/ecosystem management: Sustainable management of habitats and sustainable use of ecosystems (Target 5, Goal 15) in Europe and Central Asia are negatively affected by most archetypes, although to different extents and with diverse resulting land use patterns across the region. For example, the *economic optimism* and *regional competition* archetypes hamper the realization of these targets due to land use intensification and degradation of natural habitats. Deforestation does not represent a major threat in most archetypes (except for *regional competition*).

Sustainable consumption and production: Sustainable consumption and production (Target 4, Goal 12) are assumed to be negatively affected by the *business-as-usual*, *economic optimism*, *regional competition* and *inequality* archetypes. In contrast, the *regional sustainability* and *global sustainable development* archetypes are assumed to have a positive impact, namely in terms of sustainable consumption (*global sustainable development*) and decreasing natural resource exploitation (*regional sustainability*).

5.3 Future impacts on nature, nature's contributions to people, and a good quality of life

Chapters 2 and 3 assessed impacts of future exploratory scenarios on nature and its contributions to people. Here we build upon and extend these assessments by reviewing integrated assessment methods and models of future impacts that attempt to represent the complex interdependencies within human and environmental systems (see **Box 5.4**). Such integrated methods and models aim to offer a more realistic assessment and set of future projections of the impact of future changes in indirect and direct drivers on biodiversity, nature's contributions to people, and a good quality of life than studies that focus on individual system components or single drivers. Integrated methods and models help to build the capacity of decision-makers to understand the full extent of future risks and vulnerabilities, rather than considering single sectors or contributions of nature to people in isolation.

5.3.1 Understanding interactions between nature and society through integrated assessment studies

This section describes future impacts on nature, its contributions to people, and a good quality of life under the different plausible futures described for Europe and Central Asia in Section 5.2. It does this by reviewing integrated modelling studies, which have been applied to exploratory scenarios for the region. The impacts are grouped according to the Europe and Central Asia scenario archetypes as far as possible. This helps to capture the range of projected impacts on nature, its contributions to people, and a good quality of life while explicitly acknowledging the uncertainties associated with them.

Box 5.4: Integrated assessment models and uncertainty.

A number of different, but related, types of “integration”, which are not mutually exclusive, have been used in the context of integrated assessments within a given study system. This includes integration of different: (i) issues or components (e.g. agriculture, markets and water); (ii) disciplinary views of a management problem (e.g. economic and ecological perspectives); (iii) processes (e.g. biological, chemical, physical, economic or social); (iv) temporal and spatial scales (e.g. from local to global); or (v) stakeholders through cooperation and knowledge transfer between modellers and stakeholders at all stages of a modelling process (Jakeman & Letcher, 2003; Kelly et al., 2013).

Integrated assessment models typically link models (numerical or expert-based) representing different sectors, e.g. agriculture, forestry, biodiversity and water, with scenarios of drivers of change, such as climate change and socio-economic change (the latter including a range of indirect drivers). Kelly et al. (2013) identified five types of integrated assessment models and provide examples of each of them:

- **System dynamics models** are particularly good for modelling feedbacks, delays and non-linear effects, and are more commonly found in climate change-related impact assessments.
- **Bayesian network models** fit probabilistic relationships between system variables, and are therefore often found in modelling assessments where uncertainty needs to be properly quantified, such as for supporting decision-making and management.
- **Coupled component models** combine models from different disciplines or sectors to derive an integrated outcome. They can incorporate or handle complex representation of system components and their interlinkages (see **Box 5.5** for an example).
- **Agent-based models** define interactions between autonomous entities in a system, often humans (individuals or groups), but also other species or biophysical entities (e.g. water). Some entities (usually humans) are agents that share the same resources, can communicate or compete and react to changes in their environment through individual and social learning.
- **Knowledge-based approaches** encode knowledge elicited from experts using a logic system to infer conclusions. They can be used to encapsulate a wide range of complex feedbacks which are difficult to incorporate explicitly in quantitative methods, but care should be taken in using such approaches where knowledge about the system is uncertain or incomplete. Such approaches are often associated with a larger representation of impact indicators including nature, its contributions to people, and a good quality of life (or a combination of all three), which is possible due to the simplified way in which system relationships are represented.

Integrated assessment models are the only approaches available to quantitatively assess future changes in socio-ecological systems that account for the non-linear, interconnected nature of their multiple components (IPBES, 2016c). However, compared with simpler, single component models (single driver versus multi-driver, or single sector versus multi-sector), integrated assessment models have increased structural model complexity adding additional uncertainty to the model outputs and their interpretation (**Figure 5.8**).

Uncertainty in model structure arises from the fact that different studies may assume different conceptual representations of reality or choose to focus on different variables and processes, which are portrayed in different ways within models. In addition, uncertainty can arise from the choice of scenarios, assumptions about initial or boundary conditions within model runs, the datasets used as inputs to models, and through error propagation within an integrated modelling framework (Alexander et al., 2017; Cheung et al., 2016; Dunford et al., 2014; Payne et al., 2015). Such uncertainty can be accessed via: (i) systematic sensitivity analysis of key parameters to highlight their relative importance in influencing the results (e.g. Kebede et al., 2015); (ii) quantification of error propagation through the linked components of the model chain (e.g. Alexander et al., 2017; Dunford et al., 2014; Prestele et al., 2016); and (iii) inter-model comparison of different types of integrated models (e.g. Alexander et al., 2017; Prestele et al., 2016)). Exploration, quantification and communication of this uncertainty in an informative and standardized way is a major challenge for current and future IPBES assessments (IPBES, 2016c).

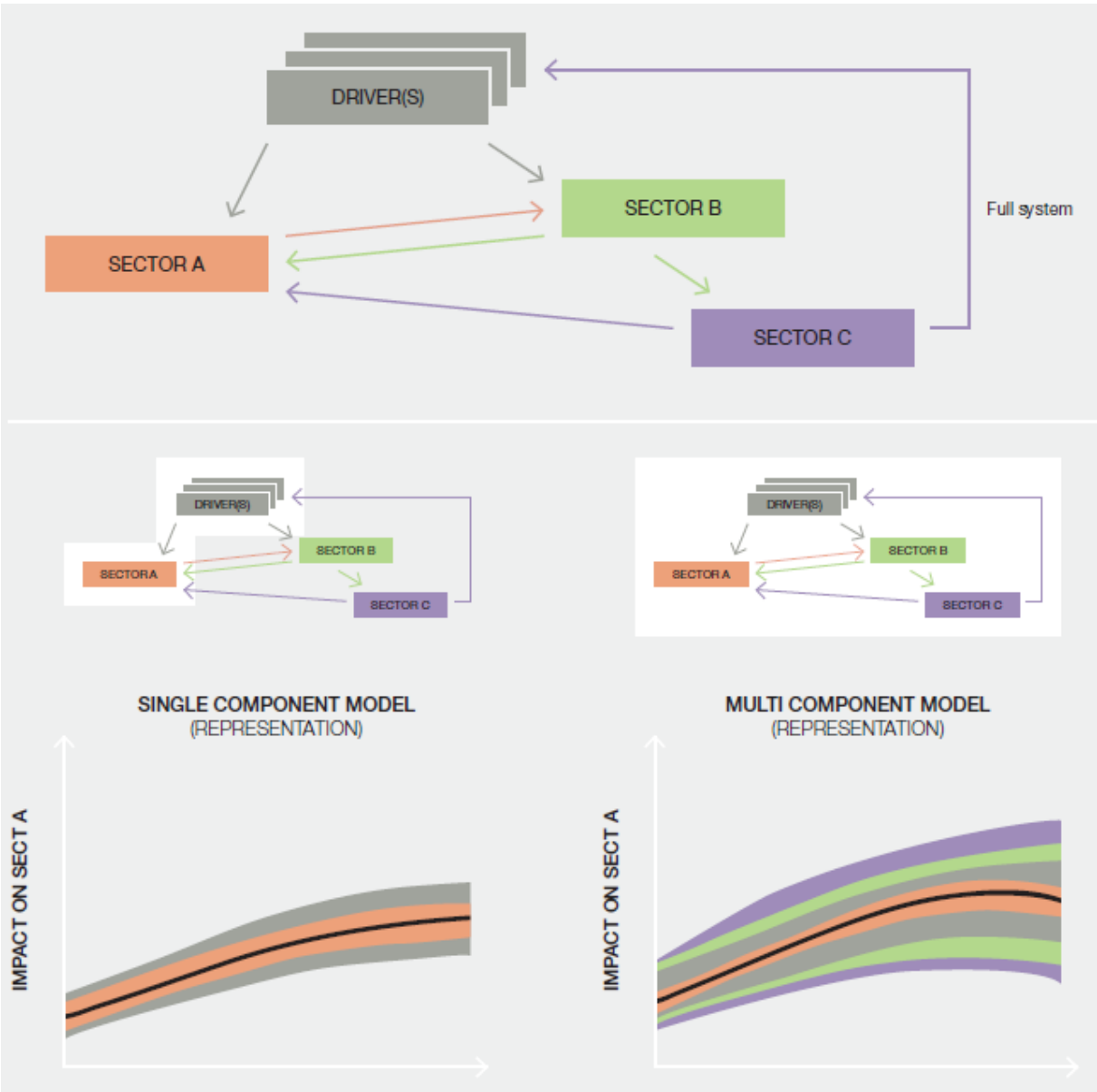


Figure 5.8: Visual representation of the impacts of a driver on a sector “A” in single component (left) and multiple component (right) models and their associated uncertainty in projecting impacts under future scenarios. A detailed visualization of a coupled-component model is given in Figure 5.13 in Box 5.5.

END OF BOX 5.4

Impacts of future changes in indirect and direct drivers on nature, its contributions to people, and a good quality of life can be studied by looking at socio-ecological systems. Interactions within socio-ecological systems are important since changes in one sector can affect another sector either directly (e.g. changes in agriculture affect biodiversity and regional hydrology), or indirectly through policy (e.g. measures designed for coastal flood defence also impact on coastal habitat) (Holman et al., 2008a, 2008b). Ignoring critical interactions and feedbacks can lead to either over- or under-estimation of impacts and the need for responses that limit societal vulnerability (Harrison et al., 2015). For example, Harrison et al. (2016) showed that there were cases where the direction of change in some sectoral indicators and indicators of nature’s contributions to people projected by single sector models was the

opposite to that projected by an integrated model (Figure 5.9). Furthermore, significant differences in the magnitude of change (>50%) were apparent even when the single-sector and integrated models agreed on the direction of change. The authors concluded that single sector studies may misrepresent the spatial pattern, direction and magnitude of most impacts and this may lead to poor decisions about adaptation.

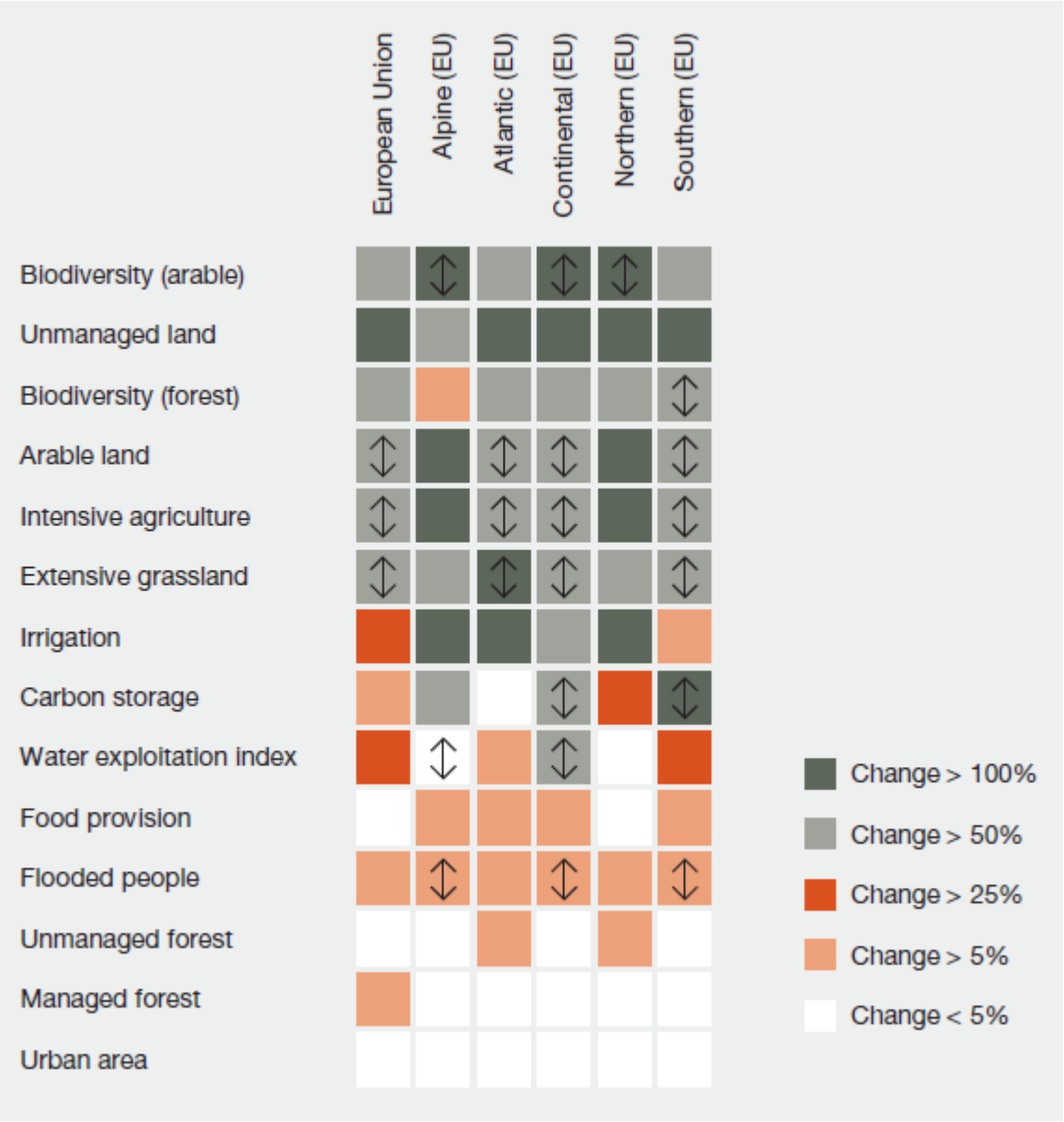


Figure 5.9: Differences between single sector and integrated models by regions within the European Union (EU). Magnitude of difference between single sector and integrated models is shown by colours. They reflect the maximum absolute change with respect to either the minimum or maximum results across multiple scenarios summed for each indicator. The double arrow symbol identifies where the direction of change (positive or negative) differs between the single sector and integrated models. Adapted from Harrison et al. (2016).

Thus, integrated studies can provide essential support to guide planning and decision-making by highlighting critical interdependencies and potential synergies and trade-offs between nature's contributions to people under different plausible futures. They also allow exploration of responses that are robust to multiple, uncertain futures, and which avoid unintended consequences (e.g.

maladaptation). This is likely to become increasingly important if future changes in indirect and direct drivers lead to amplified interdependencies between different sectors.

26431

26432 5.3.2 Review of integrated assessment studies for Europe and Central Asia

26433 A formal review of the literature on integrated modelling of impacts on nature, its contributions to
26434 people, and a good quality of life for Europe and Central Asia was carried out using the Scopus
26435 database. This was complemented with extensive searches using the IPBES expert network and
26436 additional efforts by the author team to reduce gaps (i.e. for Central Asia and marine ecosystems). The
26437 review applied a broad definition of integrated assessments as described in **Box 5.4**. Articles were
26438 screened to include only those that included projections of future impacts of multiple drivers on
26439 multiple components of nature and its contributions to people.

26440 As the majority of impact assessment studies still rely on single component models (Harrison et al.,
26441 2015), only 37 articles were found from both the formal and informal reviews that met the review
26442 criteria. However, these 37 articles led to a total of 3,151 entries in the review database representing
26443 different combinations of integrated approaches, scenarios, regions and modelled system indicators
26444 for nature, its contributions to people, and a good quality of life.

26445 *Spatial coverage:* The information gathered ranged from subnational studies conducted at relatively
26446 local scales to global assessments providing information for Europe and Central Asia. However, for
26447 studies conducted at the subregional or local levels, the review showed a very strong bias towards
26448 studies conducted in Western Europe (57%) versus studies conducted in other subregions (Eastern
26449 Europe 6%, Central Europe 6%, Central Asia 6%). This highlights that integrated assessments are rare
26450 in Eastern Europe and Central Asia, with most impact studies usually only considering one driver, most
26451 typically climate change. Of the integrated studies that were found for these subregions, trends for
26452 nature's non-material contributions to people indicators were absent.

26453 *Model type coverage:* The review revealed that the majority of integrated studies in Europe and Central
26454 Asia use a coupled-component approach (76%). Other integrated approaches found in the review
26455 include system dynamic approaches (7%) and knowledge-based approaches (13%).

26456 *Driver coverage:* A range of indirect and direct drivers were represented in the review of integrated
26457 modelling studies. The most common combination of direct drivers was climate combined with
26458 another driver (62%), mainly land use (or land management), with a smaller number of studies
26459 combining climate with resource use (12%), pollution (7%) or the effect of invasive alien species (<1%).
26460 This supports the finding in Section 5.2.1 of the dominance of climate change studies in the literature.
26461 Indirect drivers (often represented as socio-economic scenarios) were included in 51% of the studies.
26462 However, combinations of indirect and direct drivers were only considered in around 15% of database
26463 entries associated with large European Union projects, such as CLIMSAVE (Brown et al., 2015; Dunford
26464 et al., 2015; Harrison et al., 2015), SCENES (Okruszko et al., 2011) and ALARM (Lorencová et al., 2016;
26465 Schröter et al., 2005).

26466 *Cross-sectoral coverage:* Most studies involved multiple sectors and investigated cross-sectoral
26467 interactions, including goal conflicts between maximizing production of nature's contributions to
26468 people and meeting environmental quality objectives (e.g. Forsius et al., 2013). The agricultural sector
26469 featured most frequently in the reviewed studies in various combinations with nature conservation,
26470 water management, forestry, tourism and energy. Combinations between fisheries, aquaculture,
26471 water management and conservation were also observed.

Cross-scale coverage: Representation of cross-scale interactions was much less frequent than cross-sector interactions. Where included, this was often implemented by combining global, downscaled climate projections with drivers directly estimated at a lower spatial scale, such as land use and pollution (Paul et al., 2012). Nested approaches for evaluating interactions across multiple scales were identified for some studies focusing on land use drivers (Maes et al., 2015). These approaches use information on indirect drivers such as demography or energy at the global and regional level to drive spatially-explicit land use models at a range of spatial scales including subnational levels.

Values coverage: The concept of value was only considered in 50% of the integrated assessment studies, with 29% including values explicitly and 21% implicitly. For example, Garcia-Llorente et al. (2012) included the concept of value explicitly when analyzing local preferences for different land use management options in two watersheds in Spain. In contrast, Ay et al. (2014) considered values only implicitly, through an assessment of model-based scenarios linking climate, land use and biodiversity. The studies included different dimensions of value: 41% used the concept of value as nature's contributions to people (i.e. anthropocentric instrumental values); 3% as nature (non-anthropocentric or intrinsic values); and 6% as good quality of life (anthropocentric relational values). Most studies focused primarily on values associated with material contributions to people (39%), followed by regulating or supporting contributions (46%), then non-material contributions (25%). The purpose or target of valuation within the scenario studies covered agriculture (21%), spatial planning (21%), biodiversity/conservation (15%) and climate change (18%). These findings show that only half of integrated assessment studies take account of the value of nature, its contributions to people, and good quality of life. This supports the finding from the review of value representation in exploratory scenarios in Section 5.2.1 that there is a significant gap in the current literature in recognizing the diversity of values (e.g. IPBES (2016b)).

5.3.3 Future trends in indicators of nature, nature's contributions to people, and a good quality of life

Out of the 37 articles found through the review, yielding 3,151 entries in our review database, only seven evaluated indicators related to a good quality of life (e.g. equity, employment, education), 30 assessed indicators of nature's contributions to people (e.g. provision of energy, food and materials, regulation of freshwater quality or learning and inspiration) and 14 evaluated nature indicators (e.g. ecosystem functioning, species population trends). Eight studies evaluated at least two indicator types, and only two studies made a holistic evaluation across the different types of indicators (nature, its contributions to people, and a good quality of life).

The trends for the different indicators are described by scenario archetype (**Figure 5.10**) and geographic region (**Figure 5.11**).

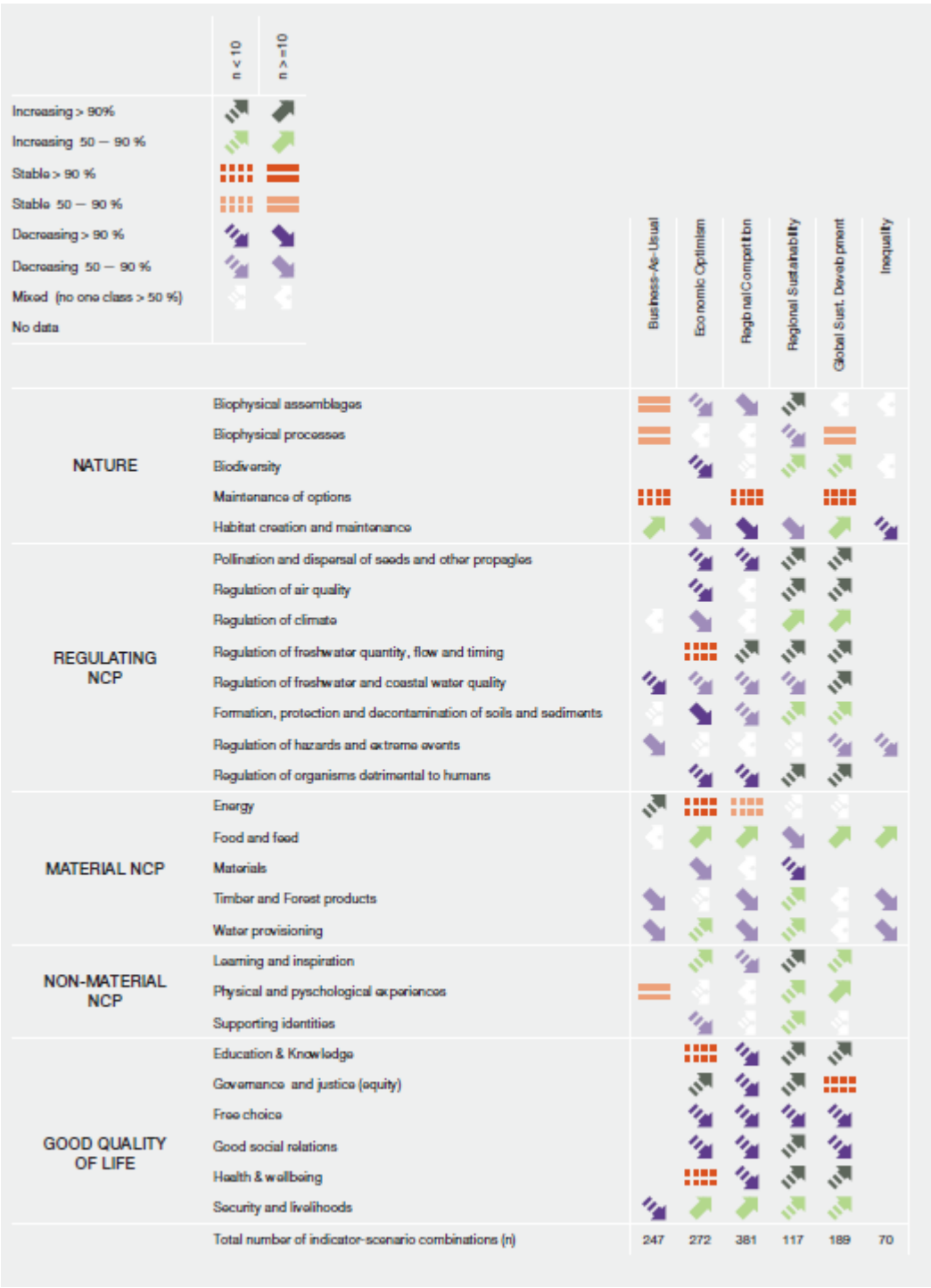


Figure 5.10: Projected future impacts on nature, its contributions to people (NCP), and good quality of life indicators according to the six scenario archetypes (in columns): *business-as-usual*, *economic optimism*, *regional competition*, *regional sustainability*, *global sustainable development*, and *inequality*. The number of indicator-scenario combinations per scenario archetype, resulting from the 37 relevant articles, is shown in the bottom row.

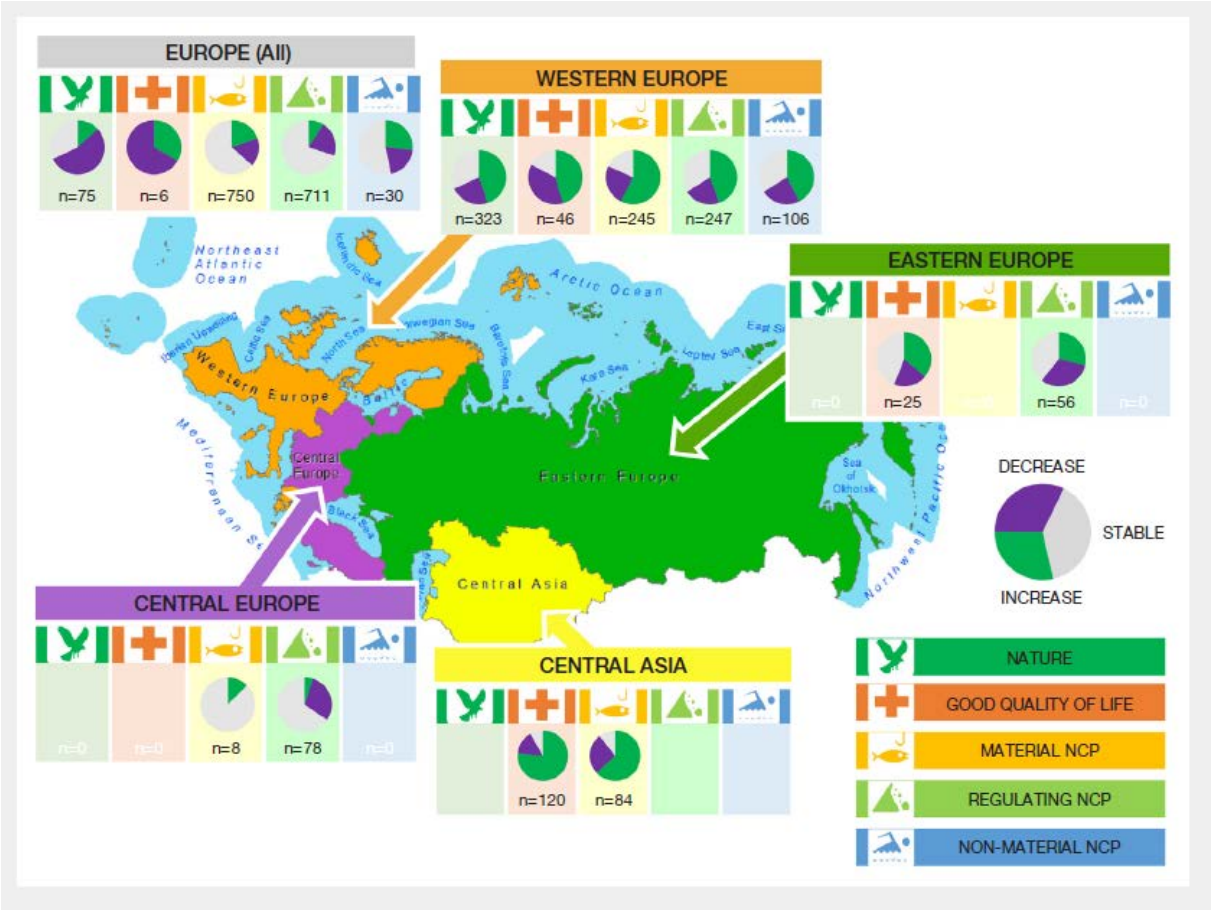


Figure 5.11: Summary of trends for groups of nature, its contributions to people, and good quality of life indicators extracted from the literature review by geographic region. Trends are summarized across the six scenario archetypes. Numbers refer to the number of scenario-indicator combinations for each indicator group and region extracted from the 37 relevant articles.

5.3.3.1 Business-as-usual

Overview: The future of the Europe and Central Asia region under the *business-as-usual* scenario archetype is complex to interpret due to the regionally variability of the results. Generally, southern parts of Western and Central Europe are associated with decreasing trends in nature indicators and nature’s material contributions to people, while northern parts are likely to benefit from enhanced material contributions. Central Europe may face moderate impacts in the future, except for nature’s regulating contributions to people which are more greatly impacted in this subregion than for other indicators. Results for Central Asia are very limited and only concern nature’s material contributions in a lake system of Uzbekistan. No results were available for Eastern Europe. Overall for all subregions, the future under this archetype is more positive than *economic optimism* scenario archetype (Section 5.3.3.2), but less than *regional sustainability* (Section 5.3.3.4).

Nature: Nature indicators assessed under *business-as-usual* in European countries generally present a stable trend (Figure 5.10 and Figure 5.11). In continental parts of Western and Central Europe, the biodiversity vulnerability index is projected to remain stable (Harrison et al., 2013). This stable trend was also confirmed in land ecosystems of Central Europe and aquatic ecosystems of southern parts of Western Europe, associated with stable diversity indexes (Hirschi et al., 2013; Kirchner et al., 2015) and stable measures of ecosystem functioning such as net primary production or community

respiration (Lazzari et al., 2014). A notable exception to these projections are forest and arable species of Alpine and southern regions of Western and Central Europe, which are projected to increase in vulnerability under this scenario archetype (Dunford et al., 2015). These findings are based on nine articles which used integrated modelling approaches and as such should be treated with caution due to the low number of studies. They can be compared to the much larger number of single component biodiversity modelling studies under *business-as-usual* scenarios reported in Chapter 3, Section 3.5, which show widespread shifts and contractions in species' distributions, and a general deterioration in conservation status.

Nature's regulating contributions to people: Trends in nature's regulating contributions to people in Western and Central Europe are complex to define as the studies using the *business-as-usual* scenario archetype projected results that were highly variable across subregions, indicators and the time period considered (**Figure 5.10** and **Figure 5.11**). For example, carbon sequestration is projected to decrease in Western and Central Europe by 2030 (-17%, representing -17 Tg C year⁻¹), but then to follow an increase to 2050 (from 7.4 to 8.7-9.2 Mt year⁻¹ (Dunford et al., 2015; Verkerk et al., 2014). For both time periods, however, Central Europe is associated with decreasing carbon sequestration for pastures and grasslands (Lorencová et al., 2016; Lorencová et al., 2013). In Central Europe, the future of other regulating contributions is unclear. For example, some authors project an increase in habitat diversity and unmanaged lands and a decrease in nitrogen leaching (Harrison et al., 2013; Hirschi et al., 2013; Lorencová et al., 2016), while other studies associate the *business-as-usual* archetype with a decline in the regulation of climate, negative impacts on nutrient cycling and stable greenhouse gas emissions from agriculture (Hirschi et al., 2013; Kirchner et al., 2015).

Nature's material contributions to people: The future of nature's material contributions to people generally varies between the northern and southern regions of Western and Central Europe, but is overall more positive than the nature indicators or regulating contributions (**Figure 5.10** and **Figure 5.11**). Several local and international studies mentioned important trade-offs between nature's material and marketable contributions to people, and its non-marketable contributions, which could explain this duality (Dunford et al., 2015; Hirschi et al., 2013; Kirchner et al., 2015; Verkerk et al., 2014). Northern and Alpine parts of Western and Central Europe are projected to benefit from the *business-as-usual* scenario archetype because of increased food production (e.g. + 3-9% agricultural biomass production) and increased forest yield by 2050 (Dunford et al., 2015; Harrison et al., 2013; Kirchner et al., 2015). In contrast, food production and forest yield are both projected to decrease in southern parts of Western and Central Europe (Dunford et al., 2015; Harrison et al., 2013). In continental parts of Western and Central Europe, the production of food remains stable but the forest area decreases, possibly because of increased roundwood production (+15%, representing +73 million m³ year⁻¹) and increased logging residues extraction (+180%, representing +25 Tg dry matter year⁻¹; Dunford et al., 2015; Harrison et al., 2013; Verkerk et al., 2014). The water exploitation index (the balance between water availability and use) is also projected to increase in Western and Central Europe, except in northern regions, where it remains stable (Dunford et al., 2015; Harrison et al., 2013). In Central Asia, the water volume of the Aydar-Arnasay lake system is projected to decrease (Rodina & Mnatsakanian, 2012).

Nature's non-material contributions to people and quality of life: Trends in nature's non-material contributions to people and good quality of life indicators under the *business-as-usual* archetype are overall stable or negative (**Figure 5.10** and **Figure 5.11**). In the future, citizens of Western and Central Europe may benefit from stable services such as recreational activities, tourism and landscape beauty, but they may be more reticent about paying for recreation in forests (Hirschi et al., 2013; Verkerk et al., 2014). On the other hand, the landscape experience index is projected to increase, which suggests a greater "naturalness" of the landscape in much of Western and Central Europe (Dunford et al., 2015).

26583

26584 **5.3.3.2 Economic optimism**

26585 *Overview:* The focus of this archetype on economic growth is reflected by an increase in the provision
 26586 of most of nature's material contributions to people (e.g. food and timber), but the challenges posed
 26587 by the environmental limits within these scenarios result in general declining trends in the majority of
 26588 the nature indicators, especially in aquatic ecosystems, and a decline in regulating contributions in
 26589 general (**Figure 5.10**). It should be noted that ecosystem functioning and regulation of air quality show
 26590 opposite directions of change compared to these overall trends. Where data are available, the
 26591 archetype leads to improvements in learning and inspiration, and physical and psychological
 26592 interactions with the environment, as society invests in education, recreation and tourism, but to
 26593 declines in indicators related to supporting identities as society becomes more globalized. Few studies
 26594 were associated with a good quality of life, but those that were available reflect the pro-growth ethos
 26595 of this archetype through considerably more increases than decreases in income levels.

26596 *Nature:* Most integrated studies under this archetype project decreases in biodiversity. This is the case,
 26597 for instance, for: coastal and wetland fishes (Forsius et al., 2013; Okruszko et al., 2011); pelagic
 26598 predators and other fish communities in southern waters of the Europe and Central Asia region
 26599 (Blanchard et al., 2012; Lazzari et al., 2014; Merino et al., 2012); birds in Western and Central Europe
 26600 (Okruszko et al., 2011); mountainous and Mediterranean species in Western Europe (Schröter et al.,
 26601 2005); coastal species of Finland (especially endangered species; Forsius et al., 2013); and an overall
 26602 decrease in biodiversity in northern Spain (Palacios-Agundez et al., 2013) (**Figure 5.10** and **Figure 5.11**).

26603 *Nature's regulating contributions to people:* Nature's regulating contributions to people in terrestrial
 26604 ecosystems are likely to be heavily impacted by future changes under the *economic optimism* scenario
 26605 archetype in Europe and Central Asia (**Figure 5.10** and **Figure 5.11**). A large number of the integrated
 26606 studies based on *economic optimism*-like scenarios project decreases in several regulating
 26607 contributions, such as carbon sequestration provided by wetlands in Western and Central Europe
 26608 (Okruszko et al., 2011), as well as by grasslands and pastures in the Czech Republic (Lorencová et al.,
 26609 2013), and crops and livestock in regions of Switzerland (Briner et al., 2013) and the Austrian Alps
 26610 (Schirpke et al., 2013). In addition, numerous local studies project decreases in air quality regulation
 26611 and erosion control in south-western Spain (Palomo et al., 2011), climate regulation in regions of
 26612 Switzerland (Hirschi et al., 2013), and protection against natural hazards and soil stability in the
 26613 Austrian Alps (Schirpke et al., 2013). However, some positive trends were projected, such as increased
 26614 carbon fluxes to Western and Central European lands in the short-term due to increased net primary
 26615 production enhanced by increased atmospheric CO₂ (Schröter et al., 2005). At the regional scale, such
 26616 decreases in regulating contributions would result in increased demand for erosion control, water
 26617 regulation or disturbance mitigation by humans (Palacios-Agundez et al., 2013). Many studies further
 26618 highlight important trade-offs between regulating and material contributions, mainly because
 26619 marketable services would be preferred over non-marketable services under some policies (Briner et
 26620 al., 2013; Hirschi et al., 2013; Schirpke et al., 2013).

26621 *Nature's material contributions to people:* The material contributions provided by land systems, such
 26622 as wood production, are often projected to increase (**Figure 5.10** and **Figure 5.11**). In western and
 26623 northern countries of Western Europe, especially in higher latitudes, forests are expected to spread
 26624 (up to +80% growth rate) because of an increased growth season, resulting in higher stemwood and
 26625 timber production (Eggers et al., 2008; Forsius et al., 2013; Schröter et al., 2005). The same trend was

described at a smaller scale in part of the Basque Country in Spain (Palacios-Agundez et al., 2013). Agricultural production is projected to increase both in Central Asia, with increased crop yields in semiarid and humid areas (Bobojonov & Aw-Hassan, 2014) and in the European Union with food production exceeding food demand (Schröter et al., 2005) (**Figure 5.10**). Some regional studies showed increased crop diversity, winter cereals production and potential distribution of bioenergy crops for northern countries of Western Europe (Forsius et al., 2013; Schröter et al., 2005) and increased agricultural production in south-western Spain (Palomo et al., 2011). A notable exception was reported for some regions of Switzerland, where food provision was projected to drastically decrease under *economic optimism*-like scenarios because of reduced financial help from the State and increased economic competition with Western and Central European farmers (-75% to -81% food production; Briner et al., 2013; Hirschi et al., 2013). In the rest of Europe, both energy supply in Spain (Palacios-Agundez et al., 2013) and hydropower across the European Union (Schröter et al., 2005) are expected to increase.

In contrast, materials production (cotton in Central Asia (Bobojonov & Aw-Hassan, 2014) and reeds in wetlands of Western and Central Europe (Okruszko et al., 2011)), is projected to decrease. Nature's material contributions to people provided by aquatic systems, such as fish provision, are also projected to decrease in Europe and Central Asia, but with great variation depending on the regions and ecosystems considered (**Figure 5.10**). The strongest decrease in fisheries production (-15%) is predicted in Spain. However, fish provision is projected to increase in Nordic countries, both in marine and riparian areas. An expected 30% to 60% increase in fisheries production is expected by 2050 in these regions, along with an increase of 26% of fishmeal production, which greatly mirror the increase of phytoplankton biomass in these areas (Blanchard et al., 2012; Forsius et al., 2013; Merino et al., 2012).

Quality of life: Most studies agree that, as a result of these trends in nature and indicators of nature's contributions to people, quality of life may be negatively affected at various scales and in all subregions of Europe and Central Asia, with a gradual disappearance of winter tourism and urban green areas in Western Europe (Forsius et al., 2013; Hirschi et al., 2013; Schröter et al., 2005), landscape beauty and tourism in regions of Switzerland (Hirschi et al., 2013), recreational activities in regions of Spain (Palacios-Agundez et al., 2013), and diving in the Mediterranean Sea (Galli et al., 2017). In contrast, farmers' revenues in Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan are projected to increase in general related to the increases in crop production (Bobojonov & Aw-Hassan, 2014) (**Figure 5.10** and **Figure 5.11**).

5.3.3.3 Regional competition

Overview: The *regional competition* scenario archetype reflects a future where regionalization occurs as a result of fragmentation and competition between (and even within) countries. It is often characterized by low technological development and limited policy effectiveness. The archetype's limited focus on the environment is reflected in declining nature indicators associated with declining biodiversity and habitat creation/maintenance. The trends in other indicators such as nature's material and regulating contributions to people are particularly variable across countries, types of indicators and the socio-economic or climatic scenario considered. However, more indicators were available for this archetype than for other archetypes, which covered the entire Europe and Central Asia region.

26668 *Nature*: Most studies assessing the future of nature indicators reported that the *regional competition*
 26669 archetype generally leads to negative impacts on biodiversity (**Figure 5.10** and **Figure 5.11**). In Western
 26670 and Central Europe, several studies project a decrease in biodiversity, especially important for
 26671 woodland and arable species (Dunford et al., 2015; Schröter et al., 2005). Northern parts of Western
 26672 and Central Europe are particularly affected as they are projected to experience increased biodiversity
 26673 vulnerability in both land and marine ecosystems, as well as a decrease in the quality of the fisheries
 26674 (e.g. species composition and mortality) and a decrease in the species of recreational interest such as
 26675 seals and cetaceans (Harrison et al., 2013; Hattam et al., 2015). In other parts of Western and Central
 26676 Europe, however, impacts on nature indicators are less clear. In western countries, plant diversity and
 26677 flowering onset are negatively affected by the *regional competition* archetype, but litter quantity,
 26678 reflecting ecosystem functioning, is projected to increase (Lamarque et al., 2014). In southern parts of
 26679 Western and Central Europe, biodiversity is projected to be more vulnerable and the Mediterranean
 26680 basin is projected to have 5.6% less plankton and bacterial biomass (in gC m⁻² (Harrison et al., 2013;
 26681 Lazzari et al., 2014; Palacios-Agundez et al., 2013)).

26682 *Nature's regulating contributions to people*: Trends in nature's regulating contributions to people
 26683 under *regional competition* are not uniform and highly depend on the types of indicators or regions
 26684 considered (**Figure 5.10** and **Figure 5.11**). European Union studies forecast declining soil organic
 26685 carbon stocks, affecting mostly croplands (between -5.4 and -5.8 Pg C by 2080) and grasslands
 26686 (between -2.7 and -2.8 Pg C (Dunford et al., 2015; Hattam et al., 2015; Schröter et al., 2005)). However,
 26687 carbon fluxes to lands and seas are projected to increase, as well as the total carbon stocks of forests
 26688 (Eggers et al., 2008; Hattam et al., 2015; Schröter et al., 2005). In southern and western parts of
 26689 Western Europe, carbon storage may remain stable or even decrease (Lamarque et al., 2014; Palacios-
 26690 Agundez et al., 2013). In the same areas, stable nitrate leaching and decreased pollination and pest
 26691 regulation can also be expected (Lamarque et al., 2014; Palomo et al., 2011). Variability across
 26692 scenarios categorized within the *regional competition* archetype also affects the projections of the
 26693 indicators. For instance, the number of people affected by flooding events in Western and Central
 26694 Europe is projected to decrease or remain stable under the *should I stay or should I go* socio-economic
 26695 scenario, whereas under the *Icarus* scenario the number of people flooded was reported to increase
 26696 (Brown et al., 2015; Harrison et al., 2013). In parts of Spain, two studies found opposite trends
 26697 regarding air quality, climate regulation, water regulation and quality, erosion control and soil fertility
 26698 even though they both used local participatory-based approaches (Palacios-Agundez et al., 2013;
 26699 Palomo et al., 2011).

26700 *Nature's material contributions to people*: Projected trends in food and feed production in Western
 26701 and Central Europe are highly dependent on the area considered (**Figure 5.10** and **Figure 5.11**). Even
 26702 though a net increase in food production is projected across Western and Central Europe under the
 26703 *regional competition* archetype (+15% increase of KCal capita⁻¹ day⁻¹ by 2050; Dunford et al., 2015;
 26704 Harrison et al., 2013), several studies show regional dependencies. The southern part of Western and
 26705 Central Europe is generally reported to experience decreased food production and reduced grazing
 26706 areas (Dunford et al., 2015; Harrison et al., 2013; Palacios-Agundez et al., 2013; Palomo et al., 2011).
 26707 Agriculture in western countries of Western Europe may also face a decline in its production because
 26708 of decreased farming intensity and decreased forage quality (Harrison et al., 2013; Lamarque et al.,
 26709 2014). However, the yield of bioenergy crops in Western and Central Europe is likely to increase
 26710 because more areas are dedicated to them, especially in northern countries of Western Europe (16 –
 26711 34% increase; Schröter et al., 2005). In Central Asia, food production is projected to increase for most
 26712 of the crops in Kazakhstan and Kyrgyzstan (e.g. +30% potatoes production by 2100), but in Tajikistan
 26713 and Uzbekistan, agricultural yield is projected to decrease for cotton (Bobojonov & Aw-Hassan, 2014).

Regional dependencies also concern other nature's material contributions to people such as wood production. Stemwood production is likely to increase in northern regions of Western Europe (up to 40 – 80% increase in Finland; Forsius et al., 2013) in contrast to southern regions where it decreases (Palacios-Agundez et al., 2013; Palomo et al., 2011). Larger studies conducted at the European Union level are highly divided on the trend in nature's contributions to people associated with forest. For instance, forest area in the European Union is expected either to decrease (Harrison et al., 2013) or to increase by 2050 (Eggers et al., 2008). Finally, a decreased biomass and abundance of fish and shellfish populations is projected in northern waters of Western Europe (Hattam et al., 2015), although studies conducted in southern parts of Western Europe show contradictory results concerning fisheries (Palacios-Agundez et al., 2013; Palomo et al., 2011).

Nature's non-material contributions to people and quality of life: As with other contributions from nature to people, the trends of non-material contributions and quality of life indicators are highly variable among the studies (**Figure 5.10** and **Figure 5.11**). The scope of the results is also limited because the only studies available for these indicators were conducted in Spain and Central Asia. The authors of the studies conducted in Spain project an increase in recreational activities, good social relations, aesthetic and spiritual value, and local identity, but a decrease in health, traditional knowledge and beach tourism (Palacios-Agundez et al., 2013; Palomo et al., 2011). In Kazakhstan and Tajikistan, farmers may benefit from increased income due to increased crop yields (Bobojonov & Aw-Hassan, 2014). In Uzbekistan, farmers may benefit from increased gross margins from food products (e.g. potatoes and wheat), but may face reduced gross margins from cotton by the 2070 – 2100 period.

5.3.3.4 Regional sustainability

Overview: The *regional sustainability* scenario archetype focuses on approaches that are customized to local conditions with a drive to local self-sufficiency. Nature's regulating contributions to people may particularly benefit from this scenario archetype as all parts of Western and Central Europe show positive trends (**Figure 5.10** and **Figure 5.11**). On the other hand, the future of nature's material contributions to people is highly area dependent and the projections of nature indicators are not clear among studies conducted at different scales. All of these projections only concern Western and Central European subregions as no data are available for Eastern Europe and Central Asia.

Nature: The future of nature indicators under the *regional sustainability* scenario archetype is not clear among the studies conducted in Western and Central Europe (**Figure 5.10** and **Figure 5.11**). The authors often use different socio-economic assumptions and climate models and their projections are applied to different areas and ecosystems. For instance, two studies project a decrease of biodiversity by 2050 – 2080 in terms of number of species and habitats, which are especially significant for birds, Mediterranean and mountain species (Okuszko et al., 2011; Schröter et al., 2005). However, in the Basque Country in Spain and Switzerland, habitat diversity and biodiversity are projected to increase substantially by 2030 – 2050 (Hirschi et al., 2013; Palacios-Agundez et al., 2013).

Nature's regulating contributions to people: Several Western and Central European studies project an increase in nature's regulating contributions to people on land ecosystems (**Figure 5.10** and **Figure 5.11**). For instance, two international studies project an increase in carbon sequestration by land systems, particularly forests, resulting in better air quality (Eggers et al., 2008; Schröter et al., 2005). In 2100, Western and Central European forests may thus accumulate up to 110 Mg C ha⁻¹ (Eggers et al., 2008). Wetlands may, however, be more vulnerable under this scenario as they store carbon at a slower rate and are less effective at removing nutrients affecting water quality (Okuszko et al., 2011). A local study from Central Europe projected similar trends with increased carbon sequestration

(approximately +25% by 2036) and more stable soils (Schirpke et al., 2013). In south-western parts of Western Europe, local studies associated with the *regional sustainability* scenario archetype showed an enhancement in several of nature's contributions to people, such as water regulation, natural hazards mitigation, soil fertility and pest regulation (Palacios-Agundez et al., 2013; Palomo et al., 2011).

Nature's material contributions to people: Impacts on nature's material contributions to people are mixed under the *regional sustainability* archetype, but a notable increase is projected for wood provision in Western and Central European countries (**Figure 5.10** and **Figure 5.11**). Forests in these countries are projected to benefit from greater area (+6-32% increase by 2080) and increment rate (+9-12% increase), leading to increased wood quantity and quality (Eggers et al., 2008; Schröter et al., 2005). Here again, wetlands may be more vulnerable as they yield reduced quantities of reed and fish provisions (Okruszko et al., 2011). Impacts on northern countries in Western Europe are positive overall, with growth of forests more pronounced than in other parts of Western and Central Europe, and with a substantial increase in the potential distribution of bioenergy crops (Eggers et al., 2008; Schröter et al., 2005). In Western Europe, forest growth rate is likely to decrease in, for example, the Alpine areas of France, Switzerland and Austria (Eggers et al., 2008; Schröter et al., 2005). Impacts on food and feed are, however, less clear as a decrease of food production (-60%) is projected in regions of Switzerland (Hirschi et al., 2013) whereas, in Austria, better forage quality and quantity suggest an increase of food production (Schirpke et al., 2013). In southern regions of Western Europe, trends in agricultural production are also variable (Palacios-Agundez et al., 2013; Palomo et al., 2011), but these local studies agree that this scenario archetype may result in decreased fisheries production.

Quality of life: Good quality of life indicators generally benefit from the socio-economic and climatic changes associated with the *regional sustainability* archetype (**Figure 5.10** and **Figure 5.11**). In two regional studies of Spain, authors project an increase in recreational activities, nature tourism, aesthetic and spiritual values, health and satisfaction with the state of biodiversity (Palacios-Agundez et al., 2013; Palomo & Montes, 2011). However, due to climate warming, an additional 25.8 million people in the European Union may face water insecurity ($< 1700 \text{ m}^3 \text{ capita}^{-1} \text{ year}^{-1}$) by 2080 (Schröter et al., 2005).

5.3.3.5 Global sustainable development

Overview: The *global sustainable development* scenario archetype has a focus on top-down governance and international cooperation to deliberately target long-term sustainability and improve quality of life. This results in impacts that are largely positive for most of the indicators of nature, of its contributions to people, and of quality of life (**Figure 5.10** and **Figure 5.11**). This scenario archetype mainly benefits regulating contributions and the nature indicators of most of the Europe and Central Asia regions. Other indicators such as material contributions and quality of life indicators are also positive overall, except in southern regions of Western Europe where negative impacts, such as a decline in water provisioning and non-material contributions, such as identity or psychological experiences, are projected.

Nature: The future of nature indicators under the *global sustainable development* archetype is generally positive for the north-western part of Western Europe, especially for marine ecosystems (**Figure 5.10** and **Figure 5.11**). The biomass of fish and shellfish populations are projected to increase and to develop enhanced traits (e.g. length, health), and to benefit from increased species diversity and greater intactness index (Hattam et al., 2015). In northern, continental and Atlantic areas of Western and Central Europe, arable and forest species are expected to remain resilient to the changes associated with this archetype (Dunford, Smith, et al., 2015). However, biodiversity vulnerability is

expected to be greater in southern and Alpine areas as well as in Germany, France and Greece (Brown et al., 2014; Dunford, Smith, et al., 2015; Harrison et al., 2013; Schröter et al., 2005). In the Mediterranean Sea, stable measures of ecosystem functioning such as net or gross primary production, and bacterial biomass suggest that the marine biodiversity of this region may not be impacted by this scenario archetype (Lazzari et al., 2014).

Nature's regulating contributions to people: Nature's regulating contributions to people, such as disturbance mitigation (Palacios-Agundez et al., 2013) and total organic carbon regulation (Hattam et al., 2015) benefit from the environmental policies and the strong cooperation between countries under this scenario archetype (**Figure 5.10** and **Figure 5.11**). Carbon storage by agriculture, forests or marine waters is projected to be enhanced across Western and Central Europe (Dunford, Smith, et al., 2015; Eggers et al., 2008; Hattam et al., 2015; Palacios-Agundez et al., 2013; Schröter et al., 2005). This estimated increase in carbon sequestration is particularly important in continental areas and may increase the tree carbon stocks of Western and Central Europe from 60 Mg ha⁻¹, as evaluated in 2000, to 131 Mg ha⁻¹ in 2100 (IPCC SRES B1 storyline; Eggers et al., 2008). Other authors also forecast an increase in soil fertility, air quality and climate regulation in the Doñana and Biscay regions and the Basque Country of Spain by 2035 - 2050 (Palacios-Agundez et al., 2013; Palomo et al., 2011), as well as an increase of erosion control provided by ecosystems by 2050 - 2080 (Lorencová et al., 2013; Palacios-Agundez et al., 2013). However, in line with the projected decrease in water availability, a growing number of forest fires is expected in the Mediterranean (Schröter et al., 2005).

Nature's material contributions to people: Most of the nature's material contributions to people in Europe and Central Asia may benefit from the *global sustainable development* scenario archetype (**Figure 5.10** and **Figure 5.11**). In Western and Central Europe, food production is projected to be enhanced due to improved agriculture practices, higher land use diversity or increased arable land area (Brown et al., 2015; Dunford et al., 2015; Harrison et al., 2013). Similarly, forest area and timber production are projected to increase substantially in Western and Central Europe (+19 Mt wood year⁻¹ by 205 (Dunford et al., 2015; Eggers et al. 2008)). There are, however, clear differences in the trends of material contributions between northern and southern countries of Western and Central Europe. Several studies highlight positive impacts in northern countries, such as increased biomass of fish and shellfish populations (Hattam et al., 2015), increased forest products (by more than 19% (Eggers et al., 2008; Forsius et al., 2013)) and increased agricultural yield (by more than 20% (Dunford et al., 2015)), all of which benefit from increased temperature and from greater afforestation efforts. Southern countries may also benefit from greater fisheries and increased food production, but a decrease in water availability in this region may lead to an additional 44.3 million people facing water insecurity (Palacios-Agundez et al., 2013; Palomo et al., 2011; Schröter et al., 2005). The future of forest production is less clear as some international studies project a decrease of this contribution of nature to people in southern countries of Western and Central Europe due to greater water stress (Dunford et al., 2015; Harrison et al., 2013), while local studies from Spain project an increase (Palacios-Agundez et al., 2013; Palomo et al., 2011). In a lake system in Uzbekistan, both the water volume of the lake and the quantity of fish inhabiting it are projected to grow (Rodina & Mnatsakanian, 2012).

Quality of life: As with other contributions of nature to people, several studies conducted in the Europe and Central Asia region project an increase of various indicators of good quality of life under the *global sustainable development* scenario archetype (**Figure 5.10** and **Figure 5.11**). These positive projections include the number of species of recreational interest, aesthetic and spiritual value, nature and beach tourism and recreational activities (Hattam et al., 2015; Palacios-Agundez et al., 2013; Palomo et al., 2011; Rodina & Mnatsakanian, 2012). Some exceptions to these beneficial impacts were reported in a study of the Basque Country in Spain, such as a decrease in traditional knowledge or a decrease of local identity due to the global nature of the scenario archetype (Palacios-Agundez et al., 2013).

26851

26852 **5.3.3.6 Inequality**

26853 *Overview:* The results associated with the *inequality* scenario archetype are very limited because only
 26854 two studies have been undertaken. Both studies were conducted in Western and Central Europe and
 26855 their projections do not encompass nature's non-material contributions to people or good quality of
 26856 life indicators. Overall, this archetype does not show a clear trend in the future of the nature indicators
 26857 or material contributions. However, a clear decline is projected in regulating contributions such as
 26858 habitat creation and maintenance, and natural hazard regulation.

26859 *Nature:* The state of the nature indicators under the *inequality* archetype is stable overall, but is clearly
 26860 area-dependent (**Figure 5.10** and **Figure 5.11**). Biodiversity is projected to be more vulnerable in the
 26861 northern and western parts of Western Europe and more resilient in the eastern and southern parts
 26862 of Western and Central Europe (Harrison et al., 2013).

26863 *Nature's regulating contributions to people:* Both studies using the *inequality* archetype agree on a
 26864 general decrease in nature's regulating contributions to people in Western and Central Europe (**Figure**
 26865 **5.10** and **Figure 5.11**). For example, flood mitigation and the proportion of unmanaged lands are
 26866 projected to decrease across these subregions (Harrison et al., 2013). The trend is less clear for the
 26867 index of land use intensity, with one study projecting a stable trend in this index (Brown et al., 2015)
 26868 and another projecting a decrease (Harrison et al., 2013).

26869 *Nature's material contributions to people:* As with the nature indicators, trends in nature's material
 26870 contributions to people in Western and Central Europe depend on the areas considered (**Figure 5.10**
 26871 and **Figure 5.11**). For the northern part of Western and Central Europe, material contributions are
 26872 generally projected to increase (Harrison et al., 2013). This is, for example, the case for intensive and
 26873 extensive farming and forest area. In southern parts of Western and Central Europe, the *inequality*
 26874 archetype is associated with a decrease in food and forestry-related contributions, but an increase in
 26875 the water exploitation index as water demand exceeds supply.

26876

26877 **5.3.3.7 Comparing impacts across subregions**

26878 Despite clear differences between impacts in nature, its contributions to people, and quality of life
 26879 indicators under the six scenario archetypes, some consistent trends within each of the subregions of
 26880 Europe and Central Asia are apparent across all or most archetypes (**Figure 5.12**). Note this figure and
 26881 accompanying text focus on trends, which broadly agree on the direction of the impact across the
 26882 scenario archetypes, sometimes with one exception. The reader is referred to the previous sections
 26883 and **Figure 5.11** for detailed descriptions of impacts within each subregion of Europe and Central Asia
 26884 for each individual scenario archetype. In **Figure 5.12** the Western Europe subregion has been sub-
 26885 divided into five areas due to the larger number of studies for this subregion, which provide greater
 26886 information on geographical variation in impacts.

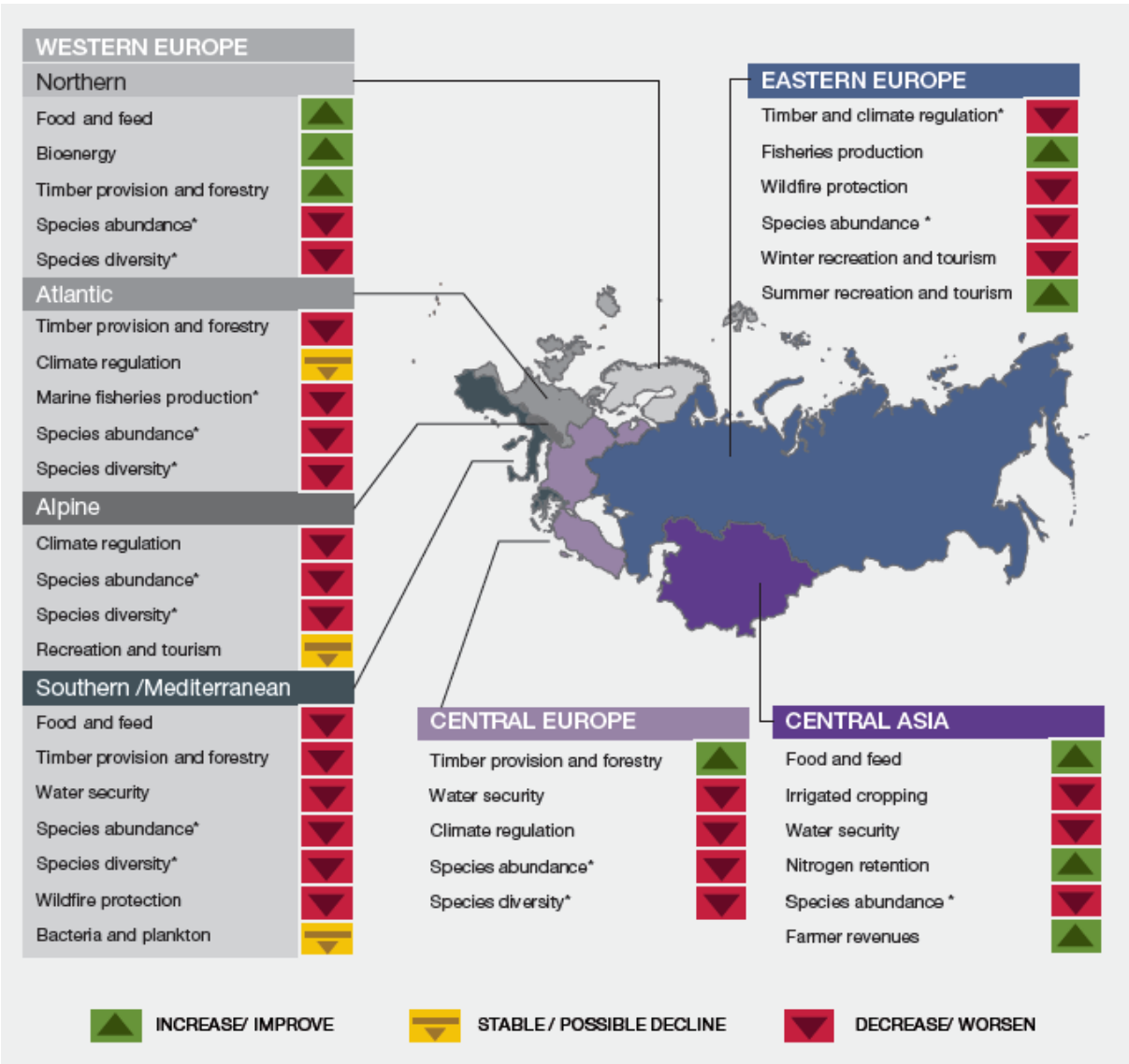


Figure 5.12: Overview of consistent subregional impacts across scenario archetypes. * = impacts on nature indicators are based on *business-as-usual* scenarios only.

Western Europe: In the northern part of Western Europe, most scenario archetypes project increases in agricultural production for bioenergy, food and feed (Brown et al., 2015; Dunford, Smith, et al., 2015; Forsius et al., 2013; Harrison et al., 2013; Schröter et al., 2005) and increases in forest area and timber provision (Eggers et al., 2008; Forsius et al., 2013; Schröter et al., 2005), with the exception of the *inequality* archetype, where it declines (Harrison et al., 2013). However, such increases in agricultural areas may result in an overall increase in biodiversity vulnerability for both land and aquatic ecosystems across archetypes (Harrison et al., 2013; Hattam et al., 2015), with the exception of *global sustainable development*, where it is more resilient (Harrison et al., 2013).

In the Atlantic region of Western Europe, forest area and yield is projected to decrease under all scenario archetypes (Dunford, Smith, et al., 2015; Harrison et al., 2013) except for *inequality*, which projects increases in forest area (Harrison et al., 2013). This results in stable or decreasing carbon sequestration in most scenario archetypes (Dunford, et al., 2015; Lamarque et al., 2014; Verkerk et al., 2014), except *global sustainable development* where it increases (Eggers et al., 2008). Enhanced growth and biomass of marine populations are projected for all archetypes (Blanchard et al., 2012; Forsius et al., 2013; Hattam et al., 2015; Lazzari et al., 2014; Merino et al., 2012), but *regional*

26905 *competition* which shows decreases in the biomass and quality of fish communities (Hattam et al.,
 26906 2015). Adaptive marine management strategies aimed at reducing nutrient loads as well as sustainable
 26907 fishery were suggested as being vitally important for the area in the future, as climate change is
 26908 expected to intensify the challenges in the area (Meier et al., 2012, 2014).

26909 Southern parts of Western Europe and the Mediterranean region show decreases in agricultural
 26910 production (Dunford et al., 2015; Harrison et al., 2013) and timber production (Dunford et al., 2015;
 26911 Harrison et al., 2013) across scenario archetypes, as well as increases in water stress (Dunford et al.,
 26912 2015; Eggers et al., 2008; Schröter et al., 2005). Greater biodiversity vulnerability in land ecosystems
 26913 (Brown et al., 2015; Dunford et al., 2015; Harrison et al., 2013), stable or slight declines in bacterial
 26914 and planktonic populations (Lazzari et al., 2014) and decreases in the number of terrestrial species
 26915 (Eggers et al., 2008; Palacios-Agundez et al., 2013; Schröter et al., 2005) are also projected across all
 26916 scenario archetypes. Some positive impacts are projected across most scenario archetypes. These
 26917 include increases in air quality regulation (Palacios-Agundez et al., 2013; Palomo et al., 2011), with the
 26918 exception of *economic optimism* (Palomo et al., 2011), and greater recreational activities and tourism
 26919 (Palacios-Agundez et al., 2013; Palomo et al., 2011), except in *regional competition* where beach
 26920 tourism declines (Palacios-Agundez et al., 2013; Palomo et al., 2011). Successful international and
 26921 cross-sectoral coordination of adaptive measures, such as in *global sustainable development*, was
 26922 projected to be crucial for dealing with these environmental challenges (Dunford et al., 2015).

26923 Projections for Alpine areas of Western Europe show consistent decreases in climate regulation
 26924 (Hirschi et al., 2013) and stable or declining landscape beauty, tourism and recreational activities
 26925 (Forsius et al., 2013; Hirschi et al., 2013; Schirpke et al., 2013; Schröter et al., 2005) across scenario
 26926 archetypes. Studies found that the farmers' awareness of the values of nature's contributions to
 26927 people can lead to more sustainable land use practices, with beneficial consequences in service
 26928 provision levels (e.g. forage quantity and quality) and nature protection (Lamarque et al., 2013).
 26929 Synergetic relationships between carbon storage (regulation of climate) and forest protective
 26930 functions (regulation of the natural hazards of avalanches and rockfalls) and nature indicators in
 26931 Central and Western European mountain forests were identified under some scenarios (Mina et al.,
 26932 2017). Adaptive management practices were also projected to alter the vulnerability of the majority
 26933 of nature's contributions to people, but no single management strategy was found to be beneficial for
 26934 all areas. Rather each site has to be considered individually as adaptive management can create shifts
 26935 in the synergies and trade-offs between contributions (Mina et al., 2016).

26936 *Central Europe*: In Central Europe, most scenario archetypes project increases in timber production,
 26937 logging residues and forest increment (Dunford et al., 2015; Eggers et al., 2008; Verkerk et al., 2014),
 26938 but decreases in carbon sequestration (Lorencová et al., 2016; Lorencová et al., 2013; Verkerk et al.,
 26939 2014). Predominantly decreasing impacts on contributions in agricultural systems were also projected
 26940 for climate, erosion and water quality regulation, but increasing impacts for food provision in the Czech
 26941 Republic (Lorencová et al., 2016; Lorencová et al., 2013). Biodiversity is also projected to be more
 26942 resilient across scenario archetypes (Dunford et al., 2015; Kirchner et al., 2015). Ruijs et al. (2013)
 26943 suggest that win-win solutions can be achieved for biodiversity and carbon sequestration on the one
 26944 hand and agriculture on the other, if nature's contributions to people are improved in areas with low
 26945 opportunity costs and agriculture is intensified in the areas with high opportunity costs.

26946 Increases in water stress were projected under dystopian scenarios (similar to the *economic optimism*
 26947 and *regional competition* scenario archetypes) (Dunford et al., 2015; Harrison et al., 2015; Kara, 2014),
 26948 leading to significant decreases in the contributions of wetlands (Okrusko et al., 2011). The studies
 26949 suggest that adaptive management is required to protect environmental flows, especially for reservoir
 26950 operation rules. Best management practices, such as vegetation management, tillage practices, early

crop sowing and erosion control in forest and agricultural fields, were also projected to regulate hydrological flows and reduce nutrient loads in lakes (European Commission, 2012a; Erol & Randhir, 2013). Alternatively, Schröter et al. (2005) found that reforestation of mountainous areas in the Danube River catchment results in shifts in the seasonality of flows and increases in water stress. Similarly, Piniewski et al. (2014) showed that a sustainable “greening” scenario would lead to lower environmental flows³⁸ than a *business-as-usual* scenario. The authors suggest that this potentially counter-intuitive result can be interpreted as a trade-off whereby producing a “greener” environment in terms of larger percentages of forests and extensive grasslands is at the cost of surface water resources and potentially aquatic ecosystems.

Eastern Europe: There were only a few integrated modelling studies available for Eastern Europe, but these projected consistent impacts across scenario archetypes for increases in fisheries production in Russia (Merino et al., 2012), showing that effective fisheries management coupled with technological advances would enable fish demand to be met. Studies also projected greater effects of wildfires on ecosystems (Chertov et al., 2014; Shanin et al., 2011) across scenario archetypes. However, the effects of forest management strategies on trade-offs between wood extraction and carbon sequestration varied by scenario archetype. Scenarios assuming natural forest development (i.e. no cuttings) resulted in the forest ecosystem becoming a carbon sink under the influence of climate change, whereas management scenarios focusing on wood harvesting resulted in the forest ecosystem becoming a carbon source (Shanin et al., 2011; Zamolodchikov et al., 2014). Reforestation of areas set aside from agricultural activities in Russia were also suggested to improve carbon accumulation in the future.

Central Asia: There were also only a few integrated modelling studies available for Central Asia. These projected increases in food and feed provisions in the short-term (2010-2040) leading to increases in farmer revenues (Bobojonov & Aw-Hassan, 2014) across archetypes. The authors suggest that farmers will face trade-offs between cash crop production and more extensive sustainable production as the profitability of different crops and resource scarcity change under climate change and different management regimes. Nitrogen retention is also projected to improve near agricultural fields due to increases in irrigation water reuse resulting from decreased water availability (Jarsjö et al., 2017). This may also increase the amount of nitrogen in soils and dissolved in the groundwater aquifers next to agricultural fields.

The region is also projected to experience greater water stress and the drying out of lakes (Medeu et al., 2015; Rodina & Mnatsakanian, 2012; Schlüter & Rüger, 2007). Sustainable integrated water and land management strategies, including water recycling, renovation of irrigation systems, installation of more efficient irrigational systems and improved restoration of pastures, were suggested as options to negate these negative effects. Capacity building (including providing farmers with access to technologies, such as improved irrigation systems) and cooperation between Central Asian countries was also considered to be crucial for tackling water stress and counteracting the negative effects of climate change on the volume of the lakes in the region.

5.3.3.8 Comparing impacts related to the different governance approaches in the scenario archetypes

Contrasting impacts are projected across the different plausible futures for Europe and Central Asia (Figure 5.10). Generally, the indicators related to nature, its contributions to people, and good quality of life show more positive impacts under the *global sustainable development* and *regional*

³⁸ Environmental flows describe the quantity, quality and timing of water flows that are required to maintain the components, functions, processes, and resilience of aquatic ecosystems.

26994 *sustainability* scenario archetypes than under the *economic optimism*, *regional competition*, *inequality*
 26995 and *business-as-usual* scenario archetypes. This is particularly noticeable for the set of indicators of
 26996 nature's contributions to people. These broad variations in impacts under different types of plausible
 26997 futures have been discussed by various authors. For example, Palacios-Agundez et al. (2013), Palomo
 26998 et al. (2011), and Schröter et al. (2005), showed that in general terms, nature's contributions to people
 26999 are expected to be more negatively influenced under socio-economic scenarios which are associated
 27000 with a reactive governance of environmental issues (e.g. *economic optimism* or *regional competition*)
 27001 than under the proactive environmental policies that are found in sustainable scenarios (e.g. *global*
 27002 *sustainable development* or *regional sustainability*).

27003 Furthermore, the main objective of the “sustainability” archetypes is to promote a more holistic
 27004 approach to managing human and environmental systems, which supports multifunctionality and
 27005 many of nature's contributions to people. Alternatively, the *economic optimism*, *regional competition*
 27006 and *inequality* scenario archetypes are motivated by economic growth or national security. These
 27007 archetypes focus more on the self-interest of individuals or “elite” groups in society and tend to
 27008 promote a more limited number of nature's contributions to people, particularly material
 27009 contributions such as agricultural and timber production. This is supported by studies that examined
 27010 trade-offs between nature's contributions to people and showed that increases in food provision
 27011 (generally associated with the expansion of agricultural land or the intensification of livestock
 27012 production and fish captures) were linked to decreasing provision of regulating contributions (e.g.
 27013 prevention of soil erosion, regulation of water quality and quantity) and nature values (e.g. ecosystem
 27014 functioning and compositional intactness indicators) (Briner et al., 2013; Dunford et al., 2015; Harrison
 27015 et al., 2013; Palomo et al., 2011; Posthumus et al. 2010). Similar trade-offs have also been identified
 27016 between other material contributions (e.g. timber extraction) and regulating (e.g. carbon storage) and
 27017 non-material contributions (e.g. aesthetic value). For example, (Dunford et al., 2015; Schirpke et al.,
 27018 2013; Verkerk et al., 2014) found that increasing wood extraction reduces the value of forests as a
 27019 carbon sink and ultimately leads to highly managed forest that are aesthetically unattractive
 27020 (decreasing its cultural/recreation values) and/or biodiversity poor.

27021 Bateman et al. (2013) demonstrated that future changes in market (e.g. agricultural production) and
 27022 non-market values (e.g. open-access recreation, urban green space and wild-species diversity) in the
 27023 UK show opposite trends depending on the severity of the environmental regulations of the scenario
 27024 considered, regardless of climate trends. The authors concluded that reactive scenarios with weaker
 27025 environmental regulations, such as *economic optimism*, tend to promote high-intensity agriculture
 27026 even at the expense of converting protected areas. This results in strong positive effects in market
 27027 values and negative effects in non-market values. Alternatively, proactive scenarios with strong
 27028 environmental regulations, such as *global sustainable development*, lead to strong positive effects in
 27029 non-market values and losses in market values. This also highlights the importance of implementing
 27030 integrated management approaches which aim to optimize both market and non-market values
 27031 simultaneously, although the authors acknowledge the difficulty in developing such approaches given
 27032 the clear trade-offs that exist between some indicators of nature and its contributions to people (e.g.
 27033 agricultural yields and wild-species diversity).

27034 A more detailed description of impacts on indicators of nature and its contributions to people across
 27035 different scenario archetypes is provided in **Box 5.5** based on an integrated modelling study for
 27036 Western and Central Europe which included multiple drivers, multiple sectors and was conducted as
 27037 part of a participatory process involving inputs from different groups of relevant stakeholders.

Box 5.5: A detailed example of the use of scenario archetypes in regional integrated assessment modelling: The CLIMSAVE Integrated Assessment Platform.

This box provides an illustrative example of scenario exploration within an integrated modelling study included in our literature review: the CLIMSAVE Integrated Assessment Platform (IAP) for Europe (defined as the European Union plus Norway and Switzerland). The CLIMSAVE IAP is an interactive, web-based, cross-sectoral modelling platform that uses a coupled-component modelling approach combining models for six sectors: urban, agriculture, water, forestry, fluvial/coastal flooding, and biodiversity (**Figure 5.13**).

There are four socio-economic scenarios embedded within the CLIMSAVE IAP, which were developed with stakeholders. These scenarios include one utopian scenario of the *global sustainable development* archetype (*we are the world*); two dystopian scenarios of the *regional competition* archetype (*should I stay or should I go* and *Icarus*) and an *inequality* archetype (*riders on the storm*). These socio-economic scenarios are combined with a range of climate change scenarios representing different emissions pathways. This allows the influence of climate and socio-economic drivers to be explored independently or in combination to answer questions related to the limits of adaptation: What influence does a green society have in an extreme climate? What are the impacts of a dystopian society under moderate climate change?

The CLIMSAVE IAP produces outputs of nature's contributions to people including: food and timber provision, water availability, climate regulation and habitat for species (Dunford et al., 2015; Dunford et al., 2015). It also provides proxy indicators related to land use composition "land use experience", non-urban land not allocated to the production of food or timber, and "land use diversity" which reflects the variety of different land uses available and is seen as a proxy for ecosystem multifunctionality. Dunford et al. (2015) modelled impacts on nature's contributions to people in the European Union as well as Norway and Switzerland for the *global sustainable development (we are the world)* and *regional competition (should I stay or should I go)* scenarios combined with both moderate and extreme climate change scenarios (**Figure 5.14**).

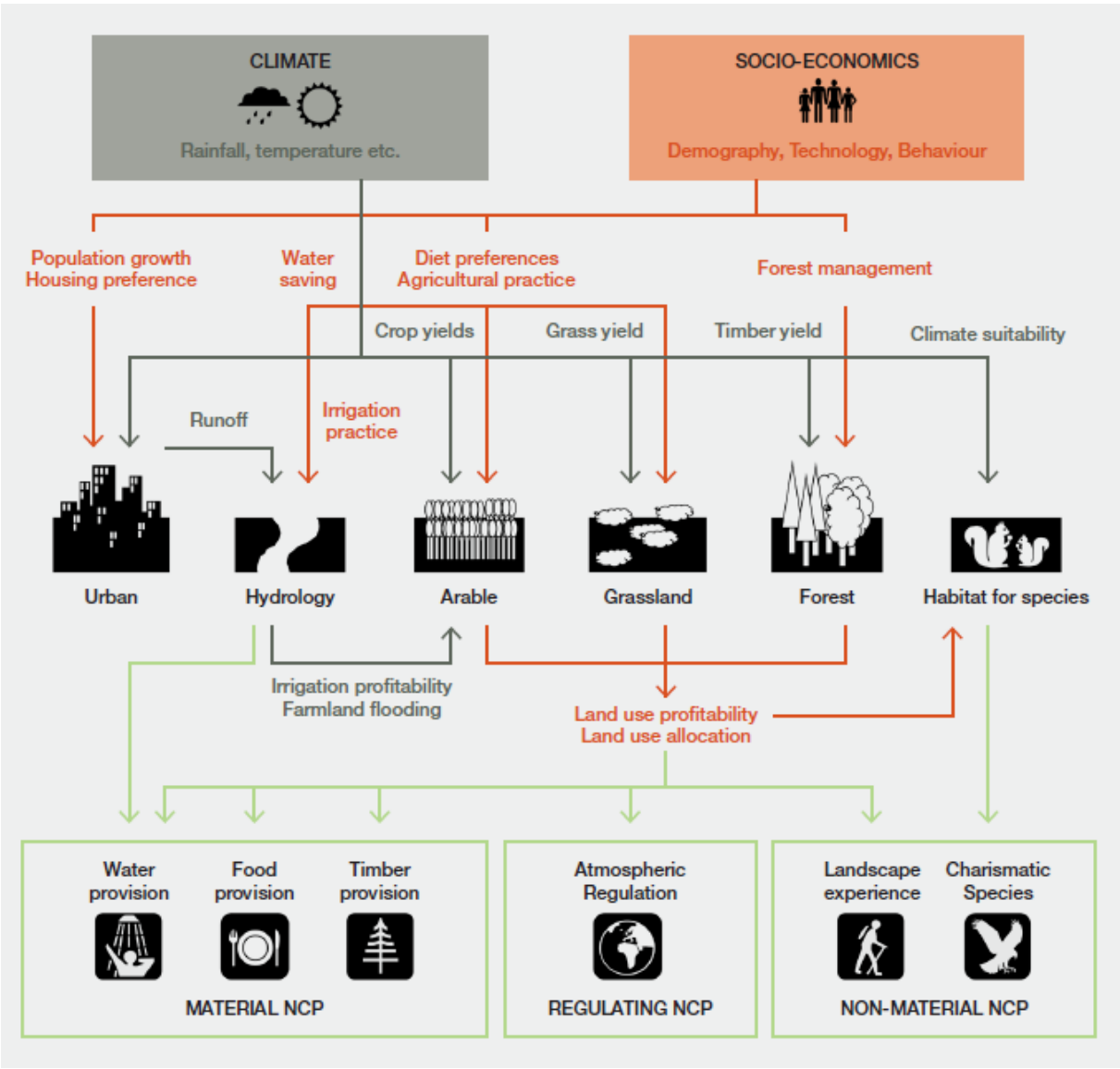


Figure 5.13: An example of an integrated assessment model (the CLIMSAVE IAP) highlighting the interlinkages between models and the outputs of nature’s contributions to people produced. Adapted from Dunford et al. (2015).

Figure 5.14 highlights the differences between plausible combinations of climate and socio-economic scenarios: the *regional competition* scenario with an extreme climate driven by high emissions and the *global sustainable development* with a moderate climate driven by lower emissions. Within both scenarios food provision targets for the European Union plus Norway and Switzerland are projected to be met by increasing the provision of food in continental, northern and Alpine regions. However, within the *regional competition* scenario, the combined pressures of failed technological innovation and an expanding population lead to significant stress being put on the agricultural system to feed the population. Lack of technological development leads to limited options to increase food production in current agricultural areas. Instead, the model projects that it is more cost-effective to expand the agricultural area leading to significant land use change reducing forested land and, thus, nature’s forest-based contributions to people. This is shown by a decline in timber provision and atmospheric regulation across these parts of Western and Central Europe (**Figure 5.14**).

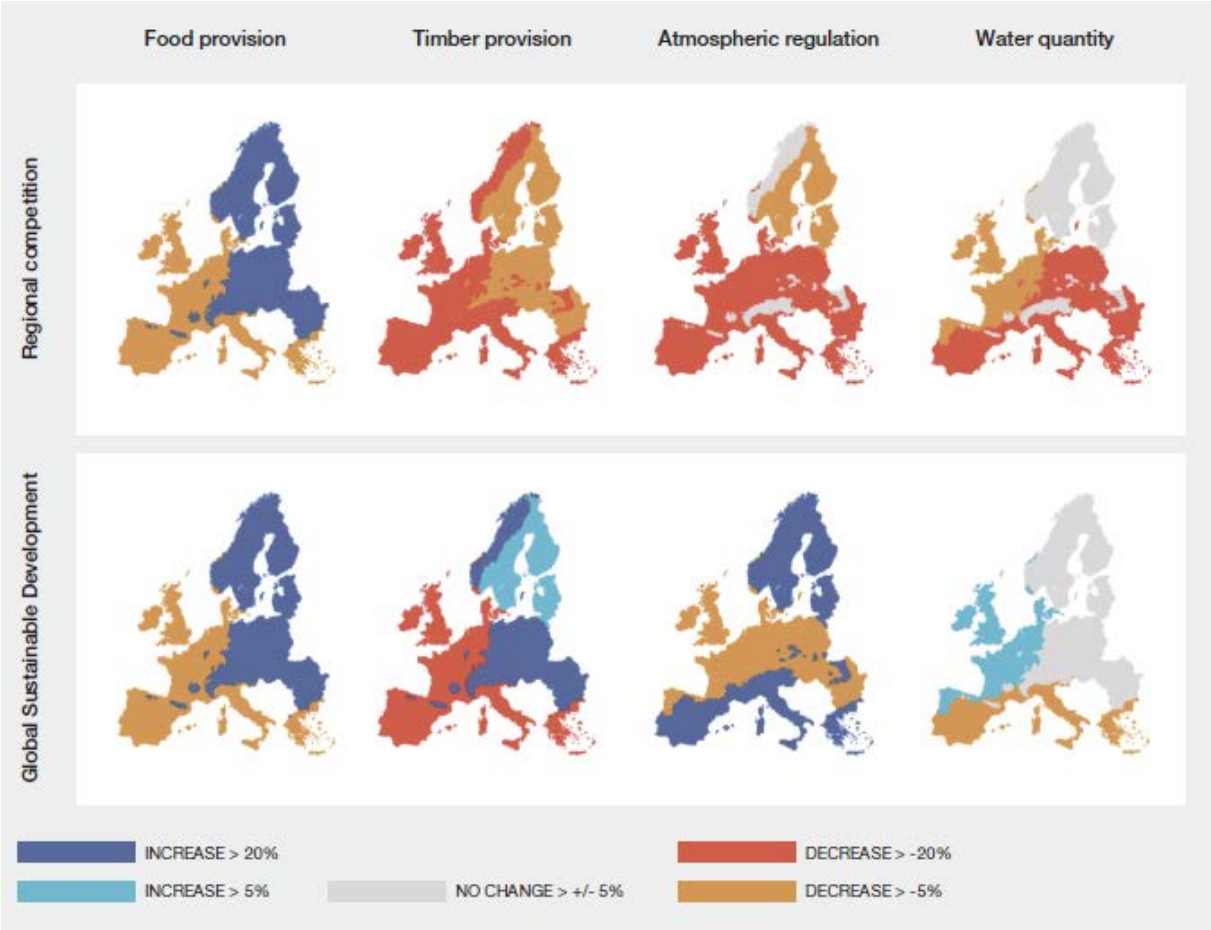


Figure 5.14: Impacts of climate and socio-economic scenarios on four indicators of nature’s contributions to people simulated using the CLIMSAVE IAP. The *regional competition* scenario archetype (*should I stay or should I go*) has been combined with an extreme climate change scenario while the *global sustainable development* scenario archetype (*we are the world*) has been combined with a moderate climate change scenario. Adapted from Dunford et al. (2015).

The *global sustainable development* scenario shows quite different impacts. As with the *regional competition* scenario, the model projects an increase in food demand due to an increase in population (although more moderate). However, this does not lead to widespread land use change, due to a high level of technological development, which makes irrigation 26% more effective and agricultural yields 15% higher due to improvements in agronomy. As this allows more food to be produced in less space and without needing to change spatial patterns of land use, there is considerably less change in habitats and their associated contributions of nature to people than was seen in the *regional competition* scenario. Instead, timber provision increases in the northern, Alpine and continental parts of Europe (in this case the European Union plus Norway and Switzerland) while atmospheric regulation increases in the northern, Alpine and southern parts. In addition, the *global sustainable development* scenario leads to a reduced level of water exploitation relative to the impacts under climate change alone because of increases in water savings through technology and behaviour change.

Results show that trade-offs are projected between nature’s contributions to people in both scenarios, particularly between southern and northern Europe with respect to agricultural- and forest-related contributions (Dunford et al., 2015). The authors show that southern Europe becomes less able to maintain competitive agriculture even under moderate climate change, while agriculture in northern Europe largely benefits from the warmer climate. In northern Europe, the scenarios result in trade-offs between projected increases in agricultural production to meet European food demand and decreases in forestry (due to agricultural competition for land) and the associated impacts on timber, recreation and cultural identity. Alternatively, in southern Europe,

projected decreases in food production are shown to have considerable impacts on social, local and national heritage and tourism-related contributions of nature to people dependent on local food production.

The analysis of Dunford et al. (2015) also highlights that, while climate scenarios have a significant influence on nature's contributions to people, socio-economic scenarios (consisting of indirect drivers) have an equally if not more significant role in modifying these contributions. Sustainability-type scenarios, where technology and behavioural change focus on reduced water use, improved irrigation efficiency, improved plant yields and less red meat consumption, considerably reduce the pressure placed on the agricultural system and lead to less dramatic land use change with less knock-on impacts on nature's contributions to people.

END OF BOX 5.5

5.3.4 Linking future impacts on nature, its contributions to people, and good quality of life, to policy goals and targets

The projections of impacts on nature, its contributions to people, and good quality of life indicators under the six scenario archetypes for Europe and Central Asia were compared with the Sustainable Development Goals and Aichi Biodiversity Targets using expert opinion to estimate the extent to which these policy goals and targets are likely to be achieved under the different scenario archetypes. Results of this analysis show relative estimations of success (projected positive impacts) and failure (projected negative impacts) to reach individual Sustainable Development Goals and Aichi Biodiversity Targets under the different scenario archetypes (**Figure 5.15**), recognizing the different time frame of the scenarios to those stated in the policy targets. As the analysis is based on expert opinion and a limited number of integrated studies, we do not interpret results for specific targets, but rather aim to provide a broad indication of the scenario archetypes which are likely to lead to success instead of failure across the full range of Sustainable Development Goals and Aichi Biodiversity Targets.

The analysis shows that the “sustainability” scenario archetypes (*regional sustainability* and *global sustainable development*) are estimated to achieve the majority of Sustainable Development Goals and Aichi Biodiversity Targets. Such scenarios attempt to provide various contributions of nature to people and aspects of a good quality of life. Thus, they represent a greater diversity of values, but often at the expense of lower, or less intensive, production of material contributions. In contrast, the fragmented world of *regional competition* is expected to lead to failure in the majority of the targets, while *economic optimism* is estimated to have a mixed level of success in achieving the Sustainable Development Goals, but would fail to achieve the majority of the Aichi Biodiversity Targets. This may be because such scenarios tend to lead to trade-offs between nature's material contributions to people and regulating and non-material contributions through prioritizing market values. Their focus on instrumental values and individualistic perspectives, with little acknowledgement of relational or intrinsic values, are unlikely to offer effective sustainable solutions to environmental and social challenges (Jacobs et al., 2016).

The reliability of the results for *business-as-usual* and *inequality* is lower than for the other scenario archetypes due to the more limited number of modelling results for these types of scenarios. Bearing in mind this lower reliability, *business-as-usual* is estimated to lead to failure in most of the Sustainable Development Goals, but mixed to positive effects on the Aichi Biodiversity Targets. The *inequality* scenario archetype shows mixed results for those policy targets for which modelled indicators were available, with slightly more failure than success for the Aichi Biodiversity Targets.



Figure 5.15: Extent to which Sustainable Development Goals (SDGs) and Aichi Biodiversity Targets (ABTs) may be reached under the different scenario archetypes. Relative estimations of success (predicted positive impacts) and failure (predicted negative impacts) based on: (i) the review of integrated scenario and modelling studies (Figure 5.10); and (ii) the extent to which Sustainable Development Goals and Aichi Biodiversity Targets prioritize diverse values of nature, its contributions to people, and good quality of life. Blue bars indicate the reliability of the estimations based on the number and consistency of the reviewed model literature.

These results are consistent with recently published research by Kubiszewski et al. (2017), who presented an assessment of the future total annual values of nature’s contributions to people under four global scenarios: *market forces* (part of the *economic optimism* archetype); *fortress world* (part of the *regional competition* archetype); *policy reform* (part of the *global sustainable development* archetype); and *great transitions* (part of the *regional sustainability* archetype). The authors show that total annual values of nature’s contributions to people decrease the most under the *fortress world* scenario, with an average reduction in the value of contributions of 29% across Europe and Central Asian countries (range from -87 to -4%). The *market forces* scenario also leads to reductions in values of these contributions, albeit slightly smaller than under *fortress world* (-19% average, -72 to +2% range). In contrast, the *policy reform* scenario results in only small changes from current 2011 values (+2% average, -10 to +9% range), while the *great transitions* scenario results in substantial improvements in values of nature’s contributions to people of +24% on average across Europe and Central Asian countries (+19 to +44% range). The authors conclude that the *great transitions* scenario (and to a lesser extent the *policy reform* scenario) embodies many of the Sustainable Development

Goals, and that, therefore, achieving the Goals would involve greatly enhanced contributions of nature to people, good quality of life and sustainability.

This section has highlighted that the choices made by decision-makers and society in Europe and Central Asia will likely lead to large differences in impacts on nature, its contributions to people, and good quality of life. Decisions related to resolving trade-offs are likely to be needed under all scenario archetypes, even sustainable futures. Such trade-offs would be more likely minimized if decision-making adopted a holistic (i.e. not siloed) approach that takes account of multiple drivers, diverse values and competing interests across sectors and regions. Approaches and actions that decision-makers can take to move society away from futures with undesirable trade-offs towards more sustainable outlooks are considered in Sections 5.4 and 5.5.

5.4 Visions of sustainable development

Sections 5.2 and 5.3 assessed what might happen in the future under different plausible, exploratory scenarios for Europe and Central Asia. The next two sections assess what society as a whole, or groups within the society, want to happen in the future, i.e. visions of desirable futures (Section 5.4, but see also 5.1.2) and pathways, which attempt to describe a course of actions to achieve such visions (Section 5.5). In particular, Sections 5.4 and 5.5 focus on visions and pathways for sustainable development that are similar to the scenario archetypes *regional sustainability* (Sections 5.2.3.4 and 5.3.3.4) and *global sustainable development* (Sections 5.2.3.5 and 5.3.3.5). Sustainable development, as conceptualized in the Sustainable Development Goals or Aichi Biodiversity Targets (see Sections 1.4.1 and 1.4.2), is a global priority, a goal shared by many countries and at the centre of the questions framing the IPBES regional assessments. Beyond this, we note that societal visions are diverse and some visions may aspire to futures not related to, or even conflicting with, sustainable development.

Visions have been developed by different stakeholder groups in Europe and Central Asia to guide and foster their perception of sustainable development and associated pathways to a sustainable future. We reviewed these visions to (i) analyze their framing of nature, its contributions to people, and good quality of life, and the linkages between these elements as described by the IPBES conceptual framework, and (ii) assess which areas for action are being given more importance (see also Section 5.1.2), based on their coverage of key sustainability and biodiversity conservation issues, as formulated by the Sustainable Development Goals and Aichi Biodiversity Targets. This analysis provides the basis for assessing the mainstreaming of goals and targets across sectors and the cross-scale coherence of the visions in Europe and Central Asia.

5.4.1 Review of Europe and Central Asia visioning and pathway exercises

Visions with associated pathways, and a minimum time frame of 15 years, were included in the review. To be inclusive, we accepted all documents stating to pursue sustainable development or, more particularly given the focus of IPBES, environmental sustainability. Individual corporate level visions for private companies were not considered. Relevant documents were identified using keyword searches in Google, Scopus and Web of Science covering both the scientific and grey literature focusing on visions, pathways, normative or target-seeking scenarios. This was supplemented by more targeted searches to fill gaps related to marine studies, wetlands, urban environments, conservation areas and indigenous and local knowledge. As accessible visions and pathways were rare for most of the Eastern Europe and Central Asia subregions, we additionally included governmental cross-sectoral

development strategies and national biodiversity strategies and action plans (NBSAPs). These focus on biodiversity conservation targets and are often developed for time frames shorter than 15 years.

For our analysis of policy coherence across scales, we also searched for and reviewed 22 global visions (for the results of the cross-scale comparison see Section 5.1.2, **Figure 5.3** and **Figure 5.4**).

Information was systematically extracted from the vision documents on the vision developers (i.e., type of actors/stakeholders), target region and geographic scale, activity sector, time frame and main goals. Furthermore, we examined the framing of nature, its contributions to people, and good quality of life in the construction of these visions, and how each vision captured the links between these elements. We also assessed visions' priority areas for action towards sustainable development and biodiversity conservation. Here, we used as a reference the list of Sustainable Development Goals and Aichi Biodiversity Targets, which were related to a dominant dimension of sustainability, that is, biophysical (Goals 6, 13-15), economic (Goals 8-10, 12), and social (Goals 1-5, 7, 11, 16) (Folke et al., 2016). Aichi Biodiversity Targets are predominantly related to the biophysical dimension.

The review resulted in 18 visions for the three subregions of Europe in general, and four governmental development strategies and ten national biodiversity strategies and action plans covering countries in Eastern Europe and Central Asia. Details of the reviewed visions and their key features are summarized in electronic Appendix 5.1. A targeted search for national or local visions was not undertaken due to language constraints, but a few thematic exceptions were added to the review. Nevertheless, we acknowledge that such visions are potentially available and could provide relevant insights. Examples of visions for topics that are rarely covered are given in boxes, namely an example for indigenous and local knowledge and the Sami people (**Box 5.6**) and for a marine protected area (**Box 5.7**). A box on visions related to bioeconomy (**Box 5.8**), addresses the special request raised in the scoping report for the Regional Assessment for Europe and Central Asia.

5.4.2 Key characteristics of visions of sustainable development for Europe and Central Asia

Notwithstanding the limited number of retrieved regional visions, the findings from the review suggest that a broad range of sectors of relevance to nature, its contributions to people (e.g. agriculture, forestry, environment, energy and fisheries), and good quality of life have already been included in visioning exercises (see electronic Appendix 5.1). Exceptions are sectors involved in the development of urban areas or transport, for which there were no sectoral visions at the broad Europe and Central Asia regional scale. However, several examples on how individual cities envision their future urban development, including transport, are available (e.g. UK; Eames et al., 2013; Tight et al., 2011). Sectoral visions were developed by multiple actor initiatives, international organizations, NGOs or business-oriented organizations.

The vast majority of visions were developed in a participatory way, including diverse stakeholder groups, for example through workshops, expert interviews and consultations. This shows that a diversity of perspectives has been incorporated in developing the visions and pathways, and indicates that deliberation of strategic planning and agenda setting is becoming mainstreamed. Consideration of indigenous and local knowledge was rarely covered explicitly in the development of visions and pathways. Most visions included stakeholder or local knowledge, but none explicitly included indigenous knowledge. However, it was not possible to determine with certainty whether the stakeholders involved in the participatory development processes were indigenous and local knowledge holders, nor whether there was a diversity of stakeholders involved (public, private, third sector stakeholders). Nevertheless, some visions explicitly including indigenous and local knowledge














and practices were found at the national level and below (see **Box 5.6**). National biodiversity strategies and action plans and governmental development plans were drafted by governmental agencies, sometimes including other actors such as academic experts and NGOs, but no further stakeholder groups.

Most visions were developed with the aim of providing policy support, namely by proposing strategic areas for action and policy instruments as part of the associated pathways (Section 5.5). For the reviewed visions, specific goals were often qualitative, providing general guidance instead of clear end-targets. An exception is the Vision for 2030 of the European Forest-based Sector (where Europe is defined as 19 European Union countries, plus Norway, Switzerland and Russia), which envisions that “Recovery, reuse and recycling of forest-based products account for 70% of all recyclable material. The remaining is used for energy production” (The Forest-based Sector, 2013). Other visions, such as the EATIP(2012) vision for aquaculture, include quantitative goals for sectoral development and growth potential, but were less specific on measures of sustainability. The absence of clear end-goals (e.g. targets that are quantitative, spatially and temporally specific, and that integrate trade-offs with other targets) can be potentially problematic, as allocation of responsibilities, assessing levels of achievement or trade-offs between goals is difficult (see Chapter 6 for further discussion).

The interdependency between nature, its contributions to people, and good quality of life was best covered by environmental visions (**Table 5.4**). Visions from the other reviewed sectors often show concern about the effects of environmental pressures, such as climate change, conversion of natural habitat to agriculture, or water pollution, and aim to reduce the impacts, but their goals often miss the underpinning role of nature in the delivery of nature’s contributions to people and the maintenance of quality of life. This lack of focus on biodiversity and nature’s contributions is also true for some cross-sectoral visions although they tend to consider both the need to reduce pressures from human activity and the need for proactive measures to enhance environmental conditions, partly also through protection and restoration (e.g., Netherlands Environmental Assessment Agency & Stockholm Resilience Centre, 2009).

Table 5.4: Presence of elements related to nature, its contributions to people, and quality of life in Europe and Central Asia visions. Information is based on vision documents covering all three European subregions (labelled “Europe”) or national biodiversity strategies and action plans and cross-sector development strategies for Eastern Europe & Central Asia (labelled “EE & CA”). The total number of visions per sector and region are indicated in each column, the number of visions including each of the elements is indicated with circles (red ● – Europe, green ● - EE & CA). Visions for the environment sector include national biodiversity strategies and action plans (n=10) for EE & CA, and visions on conservation areas (n = 1), biodiversity (n = 1) and environment in general (n = 1) for Europe.

	Cross-sector	Agriculture	Fisheries	Energy	Forestry	Environment	Number of visions
Number of visions	Europe: 5 EE & CA: 4	Europe: 5 EE & CA: 0	Europe: 1 EE & CA: 0	Europe: 1 EE & CA: 0	Europe: 3 EE & CA: 0	Europe: 3 EE & CA: 10	Europe: 18 EE & CA: 14
Nature	●●● ●●●●	●●●●			●●●	●●● ●●●●●●●●●●	Europe: 13 EE & CA: 14
Regulating contributions	●●● ●●	●●●●			●●●	●●● ●●●●●●●●●●	Europe: 13 EE & CA: 12
Material contributions	●●●●● ●●●●	●●●●●	●		●●●	●●● ●●●●●●●●●●	Europe: 17 EE & CA: 14

Non-material contributions	 					 	Europe: 13 EE & CA: 7
Quality of Life	 					 	Europe: 14 EE & CA: 14

27287

The sectoral visions exhibit certain foci. The provision of food, fibre, water and energy (including biofuels), climate change mitigation, and transition to sustainable production modes and consumption were the prevalent goals among reviewed visions. In this respect, most visions focused on material and nature's regulating contributions to people, namely climate regulation, water regulation, natural hazard regulation and soil protection. Nature's non-material contributions to people often focused on physical and psychological experiences, such as recreation.

The development strategies for Kazakhstan, Uzbekistan, Russia and Belarus focus on economic and social sustainable development. Although these are cross-sectoral visions, the sectors are addressed independently from one another, masking potential trade-offs and synergies between different goals. Sectoral strategies focus on resource extraction and production, with an emphasis on mining, water and intensive agriculture and intensive forestry. Environmental aspects of the visions relate to the control of pollution and waste. The national biodiversity strategies and action plans for the countries of Eastern Europe and Central Asia provide extensive descriptive information on the status of biodiversity using Red List approaches as a baseline for their primary goal to stop biodiversity loss, mostly based on the rational of intrinsic values of biodiversity. The concept of ecosystem services (or nature's contributions to people) is hardly mentioned at all. Recent national biodiversity strategies and action plans are mostly aligned with the Aichi Biodiversity Targets and, in some cases, also with Sustainable Development Goals-relevant targets related to poverty alleviation; but not to vulnerable groups and gender, with the exception of Georgia. Most national biodiversity strategies and action plans express strong optimism towards achieving conservation as a side effect of economic development. At the same time, consequences of development such as extractive processes, e.g. mining, overexploitation, pollution or fragmentation, are named as some of the key drivers of biodiversity loss.

27311 **Box 5.6: Visions including indigenous and local knowledge: an example from the Sami people.**



Photo by Geir Rudolfson

A number of stakeholder reports and studies from Sweden (The Sami Parliament, 2009), Finland (e.g. Kittilä et al., 2006) and Norway (Norske Samers Riksförbund, 2008) reflect knowledge from the Sami people. The Sami Parliament's Living Environment Program (The Sami Parliament, 2009) for Sweden provides a vision, which focuses on both sustainable nature and culture: "We wish to live in a resilient Sápmi which is rooted in both healthy nature and a living (thriving) Sami culture. People and nature shall have a long-term capacity to renew themselves and to sustainably evolve even in times of significant changes. Both aspects – nature and culture – shall be experienced as enriching for the surrounding world".

The vision specifically mentions protection of habitats and ecosystems, and states that "All activities are conducted according to the precautionary principle. Use of natural resources is conducted sustainably and with a long-term perspective. Nature is kept clean from non-degradable waste and from materials which threaten biological diversity or human health". Sustainable use of forests is emphasized: "both the forest structure, biological diversity, supply of lichens and connectedness with other important grazing grounds shall be protected", but linked to the needs of the reindeer herding industries as found by (Sandström et al., 2016). "Among other things this means that trees are left to grow old, there is no clear-felling and infrastructure such as roads and windmill-parks are scarce or adapted to the needs of the reindeer".

END OF BOX 5.6

Box 5.7: Visions for marine protected areas in France.



Photo by Anthony Caro

In France, including its overseas territories, the Ministry of Ecology, Sustainable development and Energy developed a national strategy for the creation and management of marine protected areas (République Française, 2012). This strategy lays down the framework and principles to set up a national network of marine protected areas. Within each marine protected area belonging to this network, a visioning exercise engaging local stakeholders (e.g. fishermen, local administrations, tourism operators, energy companies) was undertaken to define the targets and sub-targets that should be reached within the next 15 years. The visions and associated targets pertain to natural heritage, water quality, natural resources, sustainable use and development, cultural heritage, education and governance. Targets can be specific to local contexts, but all marine protected area visions link and integrate the protection and management of marine natural resources and heritage, sustainable development and cultural heritage. The visions included targets for maintaining or improving habitats, species and communities to ensure that they achieve a good conservation status to maintain high levels of biodiversity and ecosystem functioning. Other biodiversity-related targets included ensuring terrestrial run-off is compatible with high standards of water quality, good conservation of marine resources, sustainable management of fisheries and the associated sector, and the promotion of economic activities which are respectful of the marine environment.

END OF BOX 5.7

5.4.3 Key global sustainability goals and targets reflected in visions for Europe and Central Asia

Overall, Europe and Central Asia visions give priority to sustainable economic growth in tandem with sustainable industrialization, sustainable agriculture, forestry, aquaculture and management of natural resources in general (see **Figure 5.3** and **Figure 5.4** in Section 5.1.2). Climate action through land use management and the increased share of renewable energy is another priority for the region (see also **Box 5.8**). Also perceived as critical is changing people's behaviour towards more sustainable consumption patterns and lifestyles. All three dimensions of sustainability are present in Europe and Central Asia visions (c), in particular the biophysical dimension linked to nature conservation and

sustainable management of natural resources, and the economic dimension linked to sustainable production and consumption.

Biodiversity related goals, such as the Aichi Biodiversity Targets, are covered to a narrower extent in the visions than the Sustainable Development Goals (**Figure 5.10** and **Figure 5.11**). The overall narrowing of biodiversity concerns towards the targets on indirect (Target 4) and direct drivers (Target 7) in visions for Europe and Central Asia, in particular market pressures from consumption patterns and direct pressures from agriculture, fisheries and forestry activity, suggests a strong regional priority on actions to mitigate the cause of environmental impacts (Strategic Goals A and B of the Strategic Plan for Biodiversity 2011-2020). Interestingly, when compared to the global visions (**Figure 5.4**), the need to eliminate harmful subsidies (i.e. Target 3) appears to be of lower priority in visions for Europe and Central Asia. This could be due to a predisposal towards positive policy formulation in countries of the region, creating new measures and actions, and lower use or acceptance of formulations for “dismantling” or “disinvestment” or “phasing out” of existing policy measures (Sanderson, 2000).

In addition, the stronger coverage of the Sustainable Development Goals, when compared to the coverage of the Aichi Biodiversity Targets, in particular of goals directly related to elements of good quality of life and to drivers of environmental degradation, could in part be explained by the framing of several visions in the former set of the Millennium Development Goals, which relied more on indicators of quality of life and less on nature indicators than the Sustainable Development Goals. Moreover, the difference in the level of coverage of sustainability and biodiversity conservation issues, as formulated by the Sustainable Development Goals and Aichi Biodiversity Targets, also argues for the need to move beyond a focus on human needs and quality of life to a more comprehensive perspective that acknowledges not only socio-ecological systems and their dynamics, but also the primary role of biodiversity in sustainable development.

Box 5.8: Increasing demand for biological raw materials in a bioeconomy context

In the scoping document for this chapter, a special request was included to “consider issues that include increasing demand for biological raw materials in a bioeconomy context (bioenergy, fibres and organic matter), and water availability.” A number of definitions exist for the bioeconomy, e.g. the OECD “refers to the set of economic activities relating to the invention, development, production and use of biological products and processes.” The European Commission (European Commission, 2012b) (p.3) defines bioeconomy as “the production of renewable biological resources and the conversion of these resources and waste streams into value-added products, such as food, feed, bio-based products and bioenergy. Its sectors and industries have strong innovation potential due to their use of science, enabling and industrial technologies, along with local and tacit knowledge.” The underlying intention is, however, similar - namely the substitution of fossil fuel resources and to close material cycles in industrial processes by using renewable resources such as plant materials like wood, agricultural crops, animal by-products and waste (Hagemann et al., 2016).

When looking, for example, at the European White Paper on the Bioeconomy (BECOTEPS, 2011), Sustainable Development Goals or Aichi Biodiversity Targets are not directly considered. However, according to a communiqué of the Global Bioeconomy Summit 2015 a sustainable bioeconomy could make essential contributions to achieving the Sustainable Development Goals as its potential is particularly geared to the Sustainable Development Goals related to food security and nutrition (Goal 2), healthy lives (Goal 3), water and sanitation (Goal 6), affordable and clean energy (Goal 7), sustainable consumption and production (Goal 12), climate change (Goal 13), oceans, seas and marine resources (Goal 14), and terrestrial ecosystems, forests, desertification, land and soil degradation, and biodiversity (Goal 15) (see El-Chichakli et al., 2016, for more details). Anand (2016) also found that the development of the bioeconomy could potentially contribute to Goals 1 (no poverty), 2 (zero hunger), 7 (clean energy), 13 (climate action), 14 (life below water) and 15 (life on land), as it facilitates access to food, drinking water, cheap energy, effective health care and sustainable agriculture through intensive use of biomass and bioenergy, and the development of biotechnologies. However, there are a

27408 number of issues resulting from an increasing demand for biological raw materials in a bioeconomy context, such
27409 as:

- 27410 • Inappropriate management of the available biomass resources. To date, one of the major obstacles in
27411 this respect is the lack of biomass utilization and management strategies that take into account the
27412 available regional resources as well as the regional technical and human capacities and infrastructures.
27413 To implement the bioeconomy while at the same time making use of the regional resources
27414 appropriately, there is a need to establish regional bioeconomy strategies (Bezama, 2016, 2017).
- 27415 • This leads to the second issue, namely the current low involvement of national and regional
27416 stakeholders in the definition of regional strategies. There is a need to establish a “regional critical mass”
27417 that defines the key issues and development aspects that should be the basis for the regional strategies.
27418 This would not only allow the definition of the regional issues, but can also be the basis for improving
27419 social acceptance towards the issue of biomass utilization in the bioeconomy field (Bezama, 2017).
- 27420 • On the other hand, there are also issues regarding the development of the industrial sector associated
27421 with the bioeconomy. The implementation of the bioeconomy strategy will not be successful if the
27422 technological development process is carried out in the traditional way. A new, more integrative
27423 technological development process is needed, which is currently being promoted by the new circular
27424 economy strategy. Such a systems perspective for technological development will foster proper
27425 integration of the industrial sector and the biomass production sector, as discussed by Hildebrandt et
27426 al. (2017).

27427 **END OF BOX 5.8**

27428

27429 *5.4.3.1 Key global sustainability goals and targets in sectoral visions*

27430 The main policy priorities identified in the different sectoral visions are matched to the Sustainable
27431 Development Goals and Aichi Biodiversity Targets in **Figure 5.16** and **Figure 5.17**. The sustainable use
27432 of terrestrial ecosystems (Goal 15) is pursued by all the reviewed agricultural visions, being therefore
27433 a key priority for this sector. Moreover, agricultural visions show a relatively balanced coverage of
27434 goals similar to the Sustainable Development Goals and their associated dimensions of sustainability
27435 (**Figure 5.16**). However, goals related to 3 to 5 on health, education and gender equity, which are
27436 associated with the social dimension of sustainability, and to 10 on reducing inequalities between
27437 countries, are virtually absent. The reviewed environmental visions agree with the agricultural visions
27438 on the need to work towards goals similar to 15 on protection and sustainable use of terrestrial
27439 ecosystems, and show a stronger emphasis on the biophysical dimension of sustainability. Cross-
27440 sectoral visions, on the other hand, appear to give lower priority to the management of nature and
27441 natural resources. All reviewed visions aim at sustainable cities (Goal 11), sustainable consumption
27442 habits and lifestyle (Goal 12) and sustainable industrialization (Goal 9).

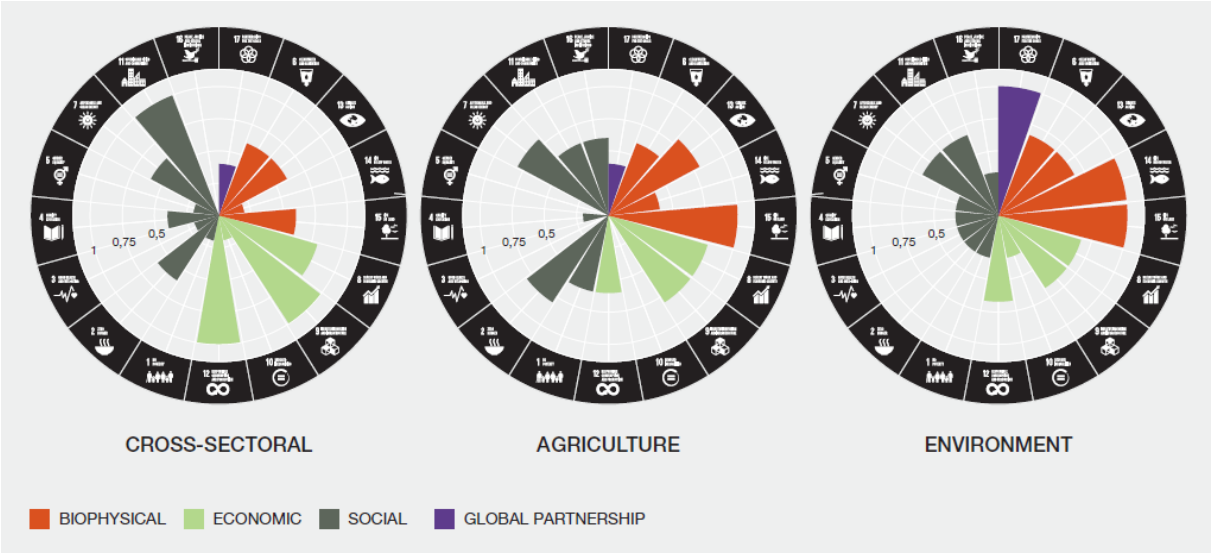


Figure 5.16: Coverage of goals similar to the Sustainable Development Goals by cross-sectoral visions (number of analyzed visions, n = 5), agricultural sector visions (n = 5) and environmental sector visions (n = 3) for the three European subregions. Dimensions of sustainability were assigned to Sustainable Development Goals based on their dominant character (Folke et al., 2016); the size of the bar towards each Sustainable Development Goal shows the proportion of visions covering that goal, ranging from 0 (not mentioned) to 1 (covered by all visions). Note that the visions often concern a different (longer-term) timescale to the Sustainable Development Goals, often until 2050.

Regarding the Aichi Biodiversity Targets, both agricultural and cross-sectoral visions focus on Targets 4 and 7, while environmental visions show a balanced coverage of all strategic goals, in particular Strategic Goal C that focuses on biodiversity condition (Figure 5.17). The weak or even inexistent coverage of Aichi Biodiversity Targets addressing Strategic Goals C, D and E, especially by the agricultural and cross-sectoral visions, could reduce the efficiency in efforts to achieve sustainability. For example, actions related to Target 15 were only found in the visions for the environmental and forestry sectors and one cross-sectoral vision, despite the urgent need to restore degraded land in Europe and Central Asia and to enhance ecosystem resilience. This includes solutions both to restore ecosystems degraded by intensive agriculture and forestry, and to enhance resilience of ecosystems affected by agricultural abandonment (Leadley et al., 2013).

The distribution of sectoral priorities not only highlights how the different sectors could promote synergies for the attainment of global goals, but also reveals potential trade-off between the sectors. Sectoral actions to promote a particular goal or set of goals may obstruct efforts from other sectors towards other goals. For instance, the promotion of biofuels by the energy sector, or food production by the agricultural or fisheries sector, may conflict with efforts to improve water savings and enhance water quality by the water sector and efforts to conserve nature when land- and seascapes are cultivated. Hence, while focusing on the most relevant goals for their sector, sectoral visions should anticipate cross-sectoral interactions and strive for smart solutions that reduce their impact on other sectors or even promote synergies with other sectors. Often these trade-offs become apparent only if the pathways, on how to achieve visions, are analyzed.

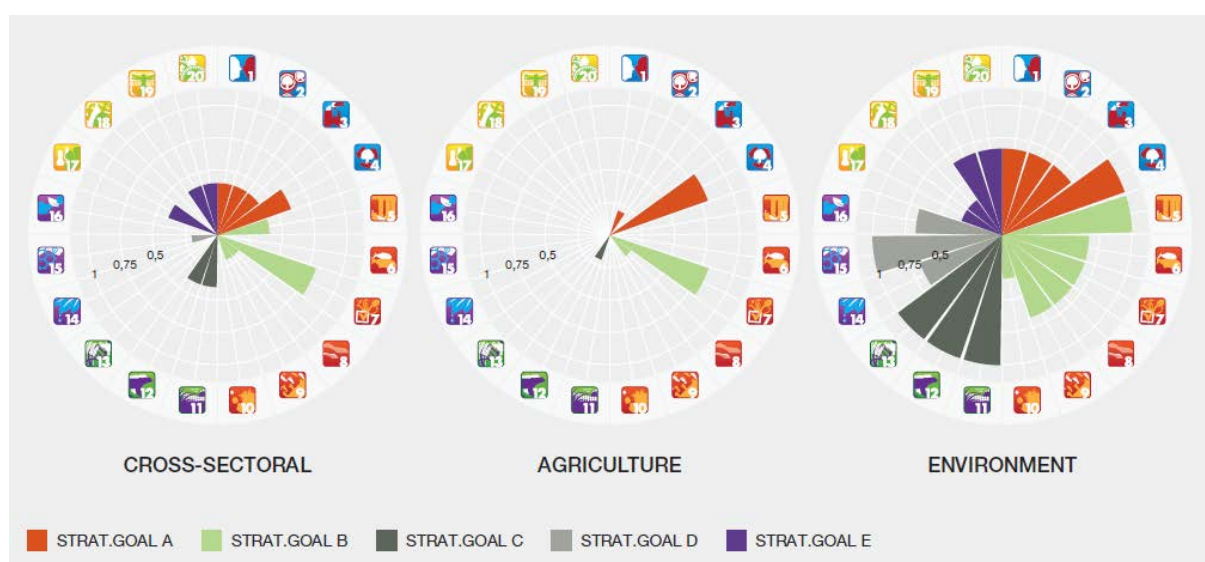


Figure 5.17: Coverage of goals similar to the Aichi Biodiversity Targets by cross-sectoral visions (number of analyzed visions, n = 5), agricultural sector visions (n = 5) and environmental sector visions (n = 3) for Europe (covering all three European subregions). Aichi Biodiversity Targets are organized by strategic goal of the Strategic Plan for Biodiversity 2011-2020, each goal addressing an area for action (A - the underlying causes of biodiversity loss, B - the direct pressures on biodiversity, C - the status of biodiversity, D - the benefits from biodiversity and ecosystem services, and E - implementation of biodiversity strategies and action plans); the size of the bar towards each Aichi Biodiversity Target shows the proportion of visions covering that target, ranging from 0 (not mentioned) to 1 (covered by all visions). Note the visions often concern a different (longer-term) timescale to the targets, often until 2050.

5.4.3.2 Key global sustainability goals and targets in regional visions

The main policy priorities identified in the different regional visions are matched to the Sustainable Development Goals and Aichi Biodiversity Targets in **Figure 5.3**, **Figure 5.4** and **Figure 5.18**. For example, the cross-sectoral strategies for Eastern Europe and Central Asia (**Figure 5.18**) show a more balanced coverage of dimensions of sustainability than cross-sectoral strategies for Europe and Central Asia in general (**Figure 5.3** and **Figure 5.4**), but also more diversification (or lower agreement) in the goals targeted by each document. Investment in clean energy (Goal 7) is the more consensual goal, pursued by all development strategies. Regarding biodiversity conservation targets, Strategic Goal D, related to nature's contributions to people and the maintenance or enhancement of key ecosystems, appears to be of higher priority than the other strategic goals (**Figure 5.19**).

National biodiversity strategies and action plans focus inherently on biodiversity conservation and, therefore, are expected to address Aichi Biodiversity Targets more thoroughly. However, while most post-2010 national biodiversity strategies and action plans for Eastern European and Central Asian countries mention the Aichi Biodiversity Targets, and the Strategic Plan for Biodiversity 2011-2020 as an overarching goal, not all establish a direct link between national goals and the targets. Those that do explicitly address a direct link, tend to cover a diverse and almost complete range of Aichi Biodiversity Targets. A similar pattern was found for national biodiversity strategies and action plans from the other subregions of Europe and Central Asia (data not shown, but available at <https://www.cbd.int/nbsap/targets/default.shtml>), which also cover a wider range of Aichi Biodiversity Targets by contrast to what was found in the visions analysis. This divergence between

national biodiversity strategies and action plans, developed by governmental institutions, and societal visions suggests that more effort is required to mainstream biodiversity and its various dimensions into strategic planning and decision-making in Europe and Central Asia.

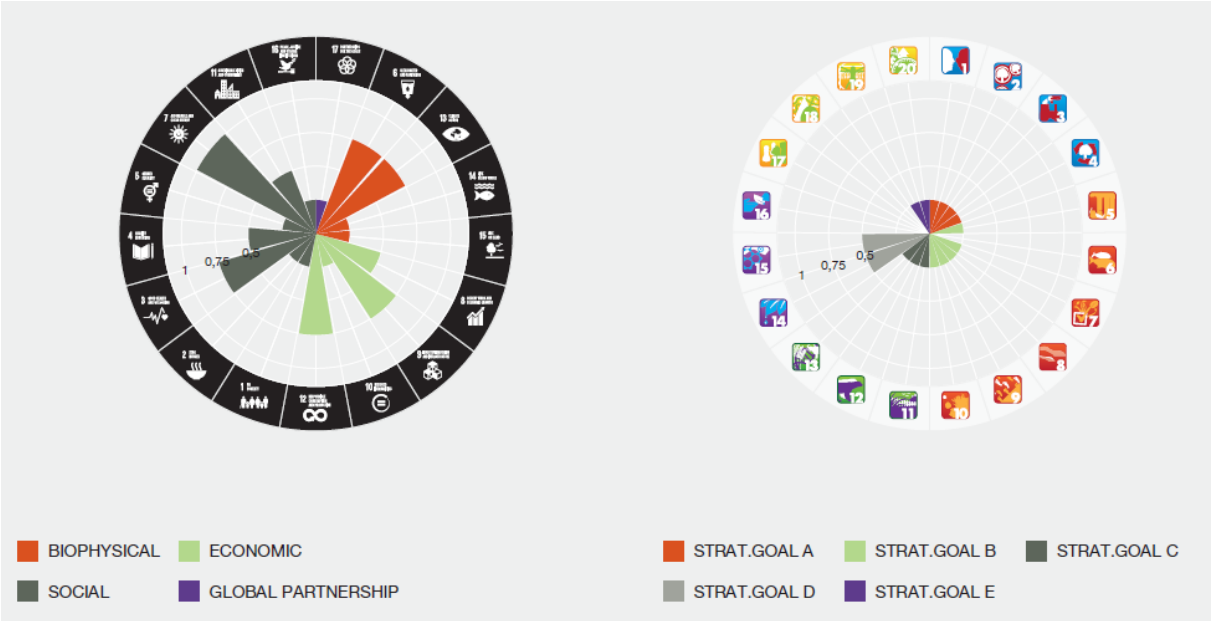


Figure 5.18: Coverage of goals similar to the Sustainable Development Goals (left) and the Aichi Biodiversity Targets (right) by cross-sectoral visions for Eastern Europe and Central Asia (number of analyzed visions = 4). Dimensions of sustainability were assigned to Sustainable Development Goals based on their dominant character (Folke et al., 2016); Aichi Biodiversity Targets are organized by strategic goal of the Strategic Plan for Biodiversity 2011-2020, each goal addressing an area for action (A - the underlying causes of biodiversity loss, B - the direct pressures on biodiversity, C - the status of biodiversity, D - the benefits from biodiversity and ecosystem services, and E - implementation of biodiversity strategies and action plans). The size of the bar towards each goal or target shows the proportion of visions covering that goal or target, ranging from 0 (not mentioned) to 1 (covered by all visions). Note the visions often concern a different (longer-term) timescale to the Sustainable Development Goals or Aichi Biodiversity Targets.

5.4.3.3 Mainstreaming interregional flows in regional visions

While there are some regional differences in visions, a similarity appears to be the disregard of Goal 10 of the Sustainable Development Goals to reduce inequalities within and among countries. This omission could have important implications in the future. For example, Kitzes et al. (2008) project that in a *business-as-usual* scenario we will require the biocapacity of two worlds to satisfy human demand for nature’s contributions to people by 2050. As shown in Chapter 2 (Section 2.2.4), the current ecological impact measured in global footprint is distributed unevenly among countries. *Business-as-usual* scenarios show that the spatial polarization between consuming high income countries (including Western Europe) and providing poorer countries (including Central and Eastern Europe) will further increase (Teixidó-Figueras & Duro, 2014). A more concrete example, is provided by Gerbens-Leenes et al. (2012), who use a scenario approach to analyze global water-use changes related to increasing biofuel use for road transport in 2030 and evaluate the potential contribution to water scarcity. The study finds that amongst the largest biofuel consuming countries, only Brazil will dispose of sufficient capacity within the country to provide the required water. France and Italy, with ongoing

biofuel production, and Spain and Germany (even without biofuel production) will depend on flows of water from neighbouring countries.

Lenschow et al. (2015) suggest that the interregional connectedness created by the flows of nature's contributions to people between countries, and even continents, gives rise to specific sustainability challenges, which require new governance solutions. Using the example of soy trade between Brazil and Germany, Lenschow et al. (2015) show that global governance approaches are likely to result in unspecific and therefore ineffective policies. The authors suggest that collaboration between nations might offer more promising opportunities for developing specific solutions. Another policy option suggested in the literature is to decouple economic growth and ecological impact. By projecting the decoupling potential of different policy mixes in the European Union, Watkins et al. (2016) find that a technical policy approach will not be sufficient to reduce environmental impacts, such as biodiversity, land use and other indicators. Instead, they suggest medium-term changes in culture and behavioural patterns to achieve sustainability. Working together towards mainstreaming Goal 10 of the Sustainable Development Goals further into visions and policies might reveal a way to deal with this new sustainability challenge.

5.5 Pathways for sustainable development

Pathways consist of different strategies for moving from the current situation towards a desired future vision or set of specified targets. They are purposive courses of actions that build on each other, from short-term to long-term actions into broader transformation (Ferguson et al., 2013; Frantzeskaki et al., 2012; Wise et al., 2014). As such, pathways (i) build or re-create and break down undesired resilience as well as reducing vulnerability through mitigation, adaptation and transformation actions that address drivers and impacts of system change; and (ii) build the system's capacities that establishes the conditions for the pathway trajectories (Poustie et al. 2016; Wise et al., 2014). Pathways studies have only been recently developed in research on nature and its contributions to people (e.g. Brown et al. (2016)), building on experience from the energy sector, sustainability studies and climate adaptation. They provide information to policy- and decision-makers on which strategies and actions may be compatible with an identified vision. Such evidence can support the design of long-term policy, allowing for innovation and creativity in the development of solutions that enhance nature and its contributions to people, and foster a good quality of life.

This section reviews pathways that have been developed to realize the visions analyzed in Section 5.4 as well as goals and targets similar to the Sustainable Development Goals and Aichi Biodiversity Targets. Furthermore, it compares the consistency of the pathways with the scenario archetypes described in Sections 5.2 and 5.3 from the perspective of the Sustainable Development Goals and Aichi Biodiversity Targets.

5.5.1 Review of global, and Europe and Central Asian pathways

As detailed in Section 5.4.1, visions and pathways that target sustainable development were selected for this review. In addition to the studies analyzed for their visions (Section 5.4), a specific review of the pathways literature was conducted focusing on local-scale studies, and especially on studies incorporating indigenous and local knowledge and social transformations, such as no-GDP growth, lifestyle change or other social transformations (electronic Appendix 5.2). Information extracted from the document sources included trade-offs addressed, actions related to land/sea use and

management, nature, its contributions to people, good quality of life and/or anthropogenic assets. Furthermore, we analyzed pathways' coherence, and whether the actions suggested by the pathways could be considered transformational. We also checked whether the pathways took into account cross-sectoral integration, including the mainstreaming of environmental objectives into other sectors, or cross-scale interactions and related trade-offs, and which values were considered and how.

As mentioned in Section 5.4, no study explicitly included indigenous knowledge at the scale of Europe and Central Asia. Noteworthy exceptions are provided in local level case studies (Hanspach et al., 2014; Oteros-Rozas et al., 2013; Palomo et al., 2011, see **Box 5.9** for further details) and a study on strategies to deal with frictions in transformation movements (Demeulenaere, 2014). Moreover, while indigenous and local knowledge does not explicitly feature in countries' development strategies or the national biodiversity strategies and action plans of Eastern Europe and Central Asia, some of them mention indigenous and local knowledge-related issues, for example, the importance of traditional crop varieties and breeds for adaptation to climate change.

More than two thirds of the pathways studies considered the concept of value. Among those considering values, this was explicit in about 80% of the cases, and implicit otherwise. Pathways studies included different dimensions of value: about 60% used the concept of value as good quality of life (anthropocentric values: relational); about 30% as nature's contributions to people (i.e. anthropocentric instrumental values) and only about 10% as nature (non-anthropocentric or intrinsic values). Most studies focused primarily on values associated with non-material contributions to people (60%), followed by regulating contributions (20%), and finally material contributions (20%).

Box 5.9: Pathways including indigenous and local knowledge and practices (based on Oteros-Rozas et al. (2013)).

This study focused on the agro-pastoral strategy of transhumance in south-central Spain as a traditional way of adapting to fluctuating and seasonal environmental factors for livestock production. This long-term practice rooted in prehistory has been shaping and maintaining biodiversity at all levels. Today this practice is declining or already abandoned because of the integration of animal production into the global market economy and the dominance of the global food system. In light of global environmental change, including climate and land use change, sustainable livestock production systems adapted to local environments have seen renewed interest. Against this background, participatory scenario planning was performed with 68 stakeholders including herders, administrators, NGOs and scientists. The aim was to envision plausible futures for transhumance and to enlighten policymaking on the maintenance of this practice along the "Consequence Drove Road", one of the largest transhumant social-ecological networks still in use in Spain. Among the specific goals was also to analyze trade-offs between different contributions of nature to people between different scenarios and their effect on a good quality of life.

Four plausible future scenarios were built, each showing clear trade-offs in the delivery of 19 studied contributions, such as food, fibre, soil fertility, fire prevention, cultural identity, local ecological knowledge and other dimensions of good quality of life. Nine management strategies for the maintenance of transhumance were identified by the stakeholders. Priority was given to implementation of payment schemes for nature's contributions to people, the enhancement of social capital among transhumants, the improvement of product marketing and the restoration of the drove roads. All the mentioned measures will enhance and make transhumance economically viable for younger generations. The results and recommendations of the participatory exercise were linked to the current reform of the European Union Common Agricultural Policy that aims for sustainable food production by strengthening links between food production and various contributions from nature to people. Thus, this study is an example of how to design pathways towards the goal/vision of sustainable livestock production by incorporating indigenous and local knowledge, a foundation in the transhumance practice, into a scenario exercise.

END OF BOX 5.9

27623 The majority of the pathways reviewed for Europe and Central Asia are open-ended storylines (without
 27624 quantification) and mainly present orientations for strategic action to address a respective vision.
 27625 Examples of pathways supported by quantification from exploratory scenarios are highlighted in
 27626 Section 5.5.5. In line with the international agenda on sustainable development (e.g. FAO, 2014; IGBP,
 27627 2009; IPCC, 2012) and the Sustainable Development Goals, the pathways broadly aim to address
 27628 several sustainability challenges, including: (i) food provision (Goal 2) while ensuring water availability
 27629 and water quality (Goal 6) and minimizing biodiversity loss (Goal 15); (ii) mitigating climate change
 27630 (Goal 13) while enhancing energy security (Goal 7), contributing to health (Goal 3) and offering
 27631 practical and workable solutions for low carbon transport systems; and (iii) promoting economic
 27632 wealth (Goals 8 and 9), relational values and equity (Goal 10). In line with these international priorities,
 27633 Europe and Central Asia visions prioritize (Section 5.1.2; **Figure 5.3**):

- 27634 • two Sustainable Development Goals relating to the biophysical dimension of sustainability:
 27635 Goals 13 (climate action) and 15 (life on land);
- 27636 • three Sustainable Development Goals relating to the economic dimension of sustainability:
 27637 Goals 8 (decent work and economic growth), 9 (industry and innovation) and 12 (responsible
 27638 consumption and production); and
- 27639 • two Sustainable Development Goals relating to the social dimension of sustainability: Goals 7
 27640 (clean energy) and 11 (sustainable cities).

27641 In addition to addressing the above challenges, the pathways also aim to mitigate trade-offs between
 27642 different aspects of nature, its contributions to people and good quality of life. Major trade-offs
 27643 relating to land, addressed by pathways studies and national biodiversity strategies and action plans
 27644 alike, concern on the one hand food, fibre and energy provisioning, and on the other hand biodiversity
 27645 and regulating contributions for the preservation of soils, water quantity and quality, and regulation
 27646 of water-related hazards, climate and air quality.

27647 In the European Union, Prins et al. (2017) and Van Zeijts et al. (2017) suggest that most future conflicts
 27648 and synergies will potentially occur in urbanized and mountainous regions. For example, in urban and
 27649 peri-urban regions, synergies may be found between cultural landscapes that are attractive for
 27650 recreation and regulating services, such as pollination. Alternatively, conflicts could arise between the
 27651 development of private landscape parks and free accessibility for recreation, and between intensive
 27652 agriculture and the attractiveness of landscapes. In mountainous areas, regulating services, such as
 27653 water retention and carbon sequestration, may be compatible with the large-scale development of
 27654 wild nature and private parks for tourism. While the development of large nature areas with natural
 27655 dynamics may conflict with the conservation of historically characteristic landscapes (Prins et al., 2017;
 27656 van Zeijts et al., 2017).

27657 In the Mediterranean region and Eastern Europe, pathways for land address additional trade-offs
 27658 resulting from land abandonment regarding biodiversity, the regulation of fire hazards, and nature's
 27659 non-material contributions to people associated with indigenous and local knowledge (e.g. Hanspach
 27660 et al., 2014; Oteros-Rozas et al., 2013). In northern areas of Western Europe (Sami land) and Russia /
 27661 Central Asia, trade-offs between exploitative land use, e.g. mining and pastoral activities by indigenous
 27662 herders are at the core of current conflicts and future pathways (Heikkinen et al., 2012; Roué & Molnar,
 27663 2017).

27664 In coastal areas, pathways address the tension between intensive food production (fisheries,
 27665 aquaculture and intensive agriculture), nature's material contributions to people and non-material
 27666 contributions associated with tourism on the one hand, and on the other hand biodiversity and

regulating contributions for the preservation of freshwater quantity and quality, coastal and marine water quality, and for hazard regulation (Palomo et al., 2011; Palacios-Agundez et al., 2013).

In the following actions within pathways regarding nature, its contributions to people, and good quality of life are described in terms of four types of narratives (Section 5.5.2), including the policy instruments considered to support these actions (Section 5.5.3). The trade-offs observed within pathways are then reviewed (Sections 5.5.4 and 5.5.5), and how these may be mitigated by cross-scale integration and the mainstreaming of environmental goals across sectors (Section 5.5.6).

5.5.2 Narratives of pathways for nature, nature's contributions to people, and a good quality of life

Pathways can be clustered into internally consistent narratives based on the alternative system properties that they mobilize through their actions and strategies (in a similar manner to how scenarios are clustered into scenario archetypes in Section 5.2 based on the changes in drivers they represent). Luederitz et al. (2016) distinguish four groups of narratives describing pathways to sustainability according to the structural and societal transformations, and associated system properties, upon which they focus:

- The *green economy* narrative addresses transitions toward decreased environmental degradation and resource depletion through green growth supported by “policy instruments that incentivize and regulate specific economic activities” (Luederitz et al., 2017).
- The *low carbon transformation* narrative encompasses all pathways focusing primarily on mitigating climate change and adapting to climate change impacts, whether at large geographic and governance scales through incentives and regulatory instruments or through local spatial planning and behavioural control. Similar to the *green economy* narrative priority is given to the top-down governance of transitions to sustainability.
- The *ecotopian solutions* narrative addresses unsustainable development and associated environmental impacts through transitions toward “greater socio-ecological integrity”. It does this by challenging current belief systems, lifestyles and living spaces with bottom-up, politically alternative initiatives of self-organization at community or neighbourhood level to work towards local-scale, self-sufficiency.
- The *transition movements* narrative also focuses on fundamental individual and social changes to propose alternatives to economic growth and globalization, and their negative social and environmental impacts. Although also starting from local, bottom-up initiatives, in contrast to *ecotopian solutions*, *transition movements* aim to scale-up to whole system transformation.

Importantly, these four narratives are complementary and non-exclusive, with specific themes such as innovation or multifunctional land use incorporated within multiple narratives.

The Europe and Central Asia pathways were classified according to the four narratives of Luederitz et al. (2016). For each narrative, alternative pathways could be identified, which vary in their sets of concrete actions and strategies (**Figure 5.19**). Below we describe the main features of each narrative adapted for the Europe and Central Asia studies in terms of their component actions for land use and land management, nature, its contributions to people, and good quality of life.

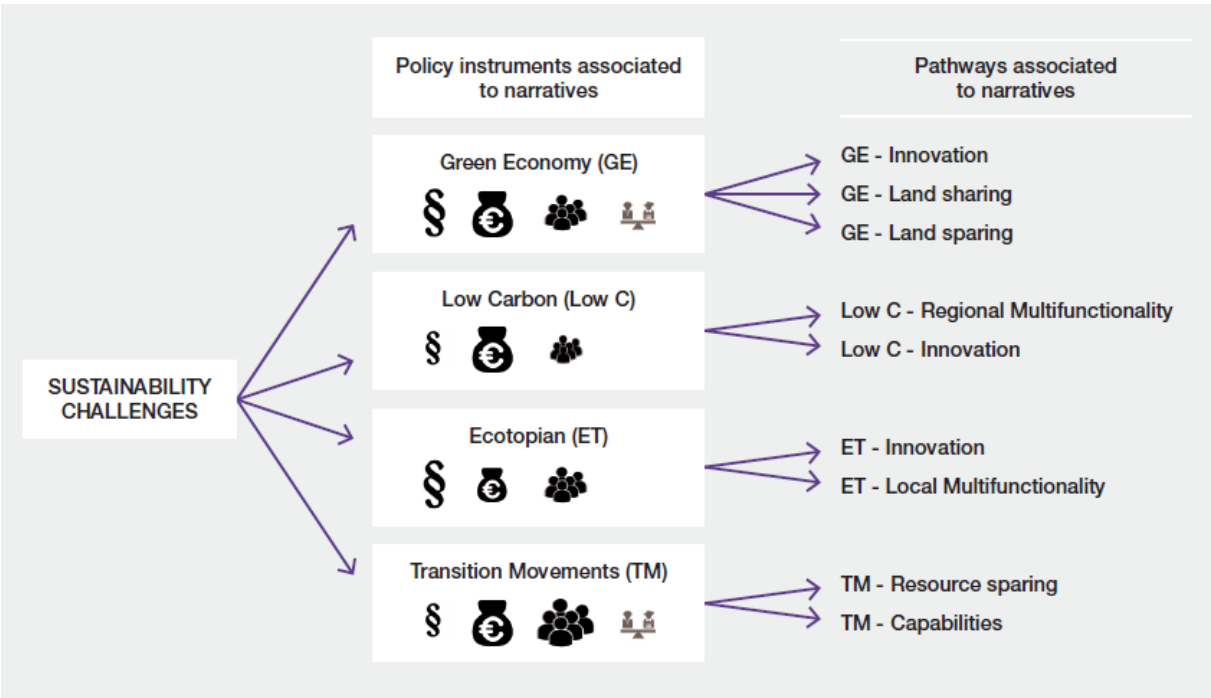


Figure 5.19: Four narratives, *green economy* (GE), *low carbon transformation* (Low C), *ecotopian solutions* (ET) and *transition movements* (TM), to address sustainability challenges for Europe and Central Asia. Each narrative is associated with different sets of policy instruments. Icons for policy instruments are defined in Table 5.5, and the size of each icon relates to the importance of each category of instruments in the narrative.

5.5.2.1 *Green economy and low carbon transformation pathways*

The majority of pathways for Europe and Central Asia fit the *green economy* or *low carbon transformation* narratives. In the *green economy* narrative, pathways rely on diversification and sustainable intensification of all production activities (agriculture, forestry, fisheries) and increased protection and restoration of biodiversity. The pathways promote improved quality and diversity of forest, agricultural and marine production, supported by healthy soils and wetlands/water. Furthermore, they contribute to employment and improved food safety, nutrition and health. As a result, these pathways rely largely on relational values (e.g. governance and justice, security and livelihoods, health and wellbeing) mentioned in around 50% of the studies, but they also consider instrumental values (e.g. nature’s material and non-material contributions to people) (ca. 30%) followed by a no-values perspective about nature (ca. 20%). Intrinsic values (e.g. biodiversity, biophysical processes) were not explicitly mentioned in any of the studies associated with the *green economy* pathway.

Pathways from the *low carbon transformation* narrative may be considered as a subset of the *green economy* narratives, with a specific focus on biofuel production, reforestation and forest management. Based on a similar set of values to *green economy*, but with a much greater focus on instrumental values, they contribute to increased regulation of climate, energy access and security, improved health (regulation of air quality), and reduced risks from regulation of hazards and extreme events. Alternative pathways within the *green economy* and the *low carbon transformation* narratives focus on the following three different sets of actions:

- 27734 • Innovation pathways within *green economy* and *low carbon transformation* narratives rely on
27735 technological innovation to address sustainability and resolve trade-offs. They do this by
27736 supporting more efficient land use allocation and management through, for example, agro-
27737 ecological practices, water-smart agriculture, precision farming, smart and sustainable forest
27738 use, increased fish farming, biofuels and biogas. These benefit nature by reducing land/sea
27739 area consumption, decreasing climate impacts, increasing climate change adaptation of
27740 production activities and supporting nature protection and restoration. While mostly focused
27741 on increasing nature's material contributions to people, and thereby employment, income and
27742 nutrition, they explicitly aim to reduce their trade-offs with regulating contributions and to
27743 improve health.
- 27744 • Multifunctionality within *green economy* and *low carbon transformation* narratives can play
27745 out at different scales. The most common multifunctionality pathways rely on *land sharing*
27746 with lower management intensity and diversification of production of nature's contributions
27747 to people within individual land/sea/water uses and across uses at landscape to regional scale.
27748 Apart from decreasing intensification, such subregional scale multifunctionality, is often
27749 associated with the promotion of conservation, restoration and sustainable use of land and
27750 wetlands. Direct benefits of these land use actions are expected for agricultural, forest, soil,
27751 water and wetland biodiversity. The improvement of nature is in turn expected to support
27752 both quality production and nature's regulating contributions to people, especially in soils and
27753 water. Further benefits are expected for climate resilience and mitigation, and for recreation.
- 27754 • Although less common, *green economy land sparing* pathways promote regional (Europe and
27755 Central Asia)-scale multifunctionality. These focus on concentrating production activities in the
27756 most favourable areas, while protecting, and in some cases abandoning, selected ecosystems
27757 or areas. According to such pathways, this land allocation and management strategy is
27758 suggested to benefit nature conservation and total provision of nature's contributions to
27759 people, at the regional scale, including in particular climate change mitigation and recreation
27760 or wilderness tourism, especially for urban dwellers. Implicit in this pathway is a lower "value"
27761 of the biodiversity of cultural landscapes compared to the resumption of "wild" biodiversity.

27762 Overall, for the *green economy* or *low carbon transformation* narratives, most actions in pathways at
27763 the Europe and Central Asia level focus on land-freshwater-sea use or management and nature and its
27764 contributions to people, with fewer actions directly targeting a good quality of life.

27765

27766 5.5.2.2 *Transition movements pathways*

27767 In contrast to the *green economy* and *low carbon transformation* narratives, pathways of the *transition*
27768 *movements* narrative involve changes in relational values towards resource-sparing lifestyles, and in
27769 some cases, they emphasize explicitly non-GDP growth. They incorporate the development of
27770 innovative forms of agriculture combining indigenous and local knowledge with technological
27771 innovations (e.g. agroecology, agroforestry, organic agriculture, urban agriculture), transport and
27772 energy models that limit impacts on nature, climate and water. Relational values are at the centre of
27773 proposed actions, including education, the incorporation of indigenous and local knowledge and
27774 cultural diversity. Enhancing quality of life, especially by supporting the Sustainable Development
27775 Goals, is complemented by a focus on reduced social inequities and full employment. These goals are
27776 enabled by new social models, which aim to reduce market globalization and interregional flows, and

support cultural identities, knowledge sharing and transformative capabilities. Here, transformative capabilities are defined as individual and collective capacities to improve and enrich their quality of life by changing factors affecting their lives, of which the environment is central. Apart from education, they include for instance social capital, local leadership and empowerment, building trust and collaboration. All types of values are represented within transitions movements pathways, with relational values having the greatest emphasis (ca. 41%) followed by instrumental (ca. 18%) and intrinsic values (ca. 9%).

Specific pathways of *transition movements* narratives focus on resource-sparing lifestyles (including e.g. food and energy), or on transformative capabilities (including common actions), though these two categories are not mutually exclusive.

- Resource-sparing lifestyle pathways emphasize change in dietary and overall consumption patterns. These changes are associated with innovative land use or management such as agro-ecological methods, including organic agriculture, possibly also in coexistence with more intensive production regionally. Other changes suggest a radically reduced energy consumption and new urban spatial structure and planning. All these changes in lifestyles are intended to have beneficial effects for biodiversity at species, habitat and landscape levels. With explicit inclusion of intrinsic and relational values, these pathways invoke a strong reliance on nature's regulating contributions to people, as well as benefits from material and non-material contributions. Together these promote all aspects of a good quality of life, including continuous education, participatory transdisciplinary research and social capital, and the preservation of cultural diversity, indigenous and local knowledge and social equity.
- Transformation capabilities pathways mostly emphasize the role of local empowerment, deliberation and social cohesion for achieving diversified, sustainable land use and livelihood strategies at the subregional scale. As such, they do not target transformation of lifestyles or economic growth *per se*, but nevertheless share many actions of resource-sparing pathways regarding quality of life as a secondary effect of social changes.

5.5.2.3 *Ecotopian solutions pathways*

Ecotopian solutions pathways share many elements with *transition movements* in terms of lifestyles, land use or management types and innovations, and social transformation. However, *ecotopian solutions* have an even stronger focus on bottom-up actions and politically alternative initiatives of self-organization than *transition movements* pathways. Similar to *transition movements*, they include all values: relational (ca. 60%), intrinsic (ca. 20%) and instrumental (ca. 20%). The inclusiveness and balance among different types of values in this pathway support sustainability efforts through changing social behaviour.

Local-scale multifunctionality is a cornerstone of *ecotopian solutions* pathways. For this, *ecotopian solutions* pathways rely on fine-grained landscape mosaics of diversified land uses with multifunctionality within individual land uses and connecting green infrastructure (e.g. corridors). They also highlight new production methods and new technologies, but in contrast to other pathway narratives, their focus is to achieve community-level food and energy self-sufficiency and the production of multiple contributions from nature to people. Two pathways can be distinguished within the *ecotopian solutions* narrative depending on whether they focus on innovation or local multifunctionality. Those pathways with a strong emphasis on innovation and associated instrumental

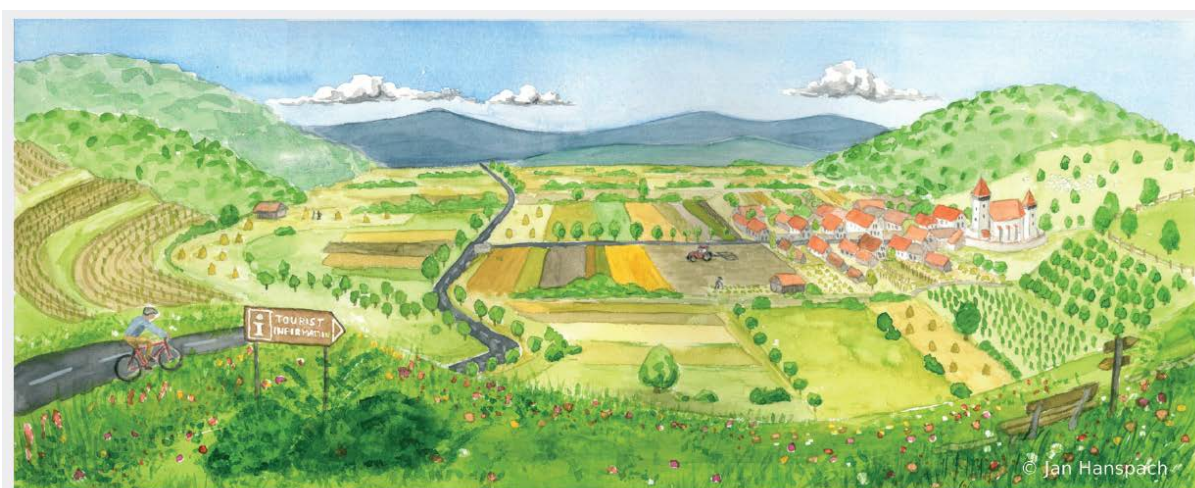
values, often along with radical social innovation and shifts in worldviews, generally focus on urban design and food production.

Unlike *transition movements* pathways, *ecotopian solutions* pathways, and specific actions therein, focus solely on local scales and may therefore only be applicable at community, or even very local levels (e.g. wealthy neighbourhoods). Scaling-up to the regional level and beyond may not be easy, especially due to trade-offs and spill-over effects (Maestre Andrés et al., 2012). For example, the pathway of local multifunctionality at the European scale (Western, Central and Eastern Europe) is not compatible with objectives of nature protection (e.g. connectivity, natural protected areas, forest biodiversity protection) or climate mitigation at the European Union level, and may ultimately increase net global trade in agricultural products (Verkerk et al., 2016).

Overall, local level studies of pathways from *transition movements* and *ecotopian solutions* narratives, and some studies of visions of social transformations towards sustainability (Capellán-Pérez et al., 2015; Davies & Doyle, 2015; Fauré et al., 2016; Robertson, 2016; Videira et al., 2014) offer a rich set of actions focusing on good quality of life, anthropogenic assets and institutions. However, in a number of cases, specific actions on land use or management, nature and its contributions to people, are lacking. Nevertheless, such studies suggest a diversity of alternative transition pathways which may act as “seeds” for future sustainability (Bennett et al., 2016), yet need to be further developed to incorporate explicit sets of actions related to land use or management, nature, and its contributions to people.

Box 5.10 summarizes a local *transition movements* pathway as a demonstration of a coherent pathway incorporating indigenous and local knowledge developed for southern Transylvania (Hanspach et al., 2014).

Box 5.10: Pathway to sustainability for southern Transylvania (based on Hanspach et al., (2014)



Alternative target-seeking scenarios for the future of rural areas in southern Transylvania were developed using a participatory process. The *balance brings beauty* scenario offers a possible pathway towards regional and local sustainability based on a complete reorientation of European Union agricultural and rural policies towards sustainability and environmentally friendly land use. Subsidies and policies foster small- and medium-scale organic farming, low-intensity forestry and the discontinuation of previously common exploitation of resources (e.g. soil, forest). This major policy change is combined with a high ability of local people to capitalize on opportunities. This is supported by a fundamental change in the social fabric; from communities that were shaped by mistrust, corruption, ethnic conflicts and poor education to communities with high social capital, mutual learning and collaboration, equality and excellent education. Importantly, knowledge and practice of

27853 traditional land use, traditions and cultural and natural heritage are maintained and people are proud of their
27854 landscape.

27855 The continuation of sustainable, small-scale farming based on indigenous and local knowledge is a keystone for
27856 this pathway. Due to pro-environmental policies, this is only organic farming, with an increase in intensity
27857 (abandoned land taken into use again). Farming is undertaken by local farmers who are well connected and
27858 collaborate. Thus, large or external farming companies have no influence on land use. Forest resources are
27859 maintained with only low-intensity harvesting. Land use and livelihood strategies are diversified (farming for
27860 crops, vineyards, orchards, hay-meadows, livestock grazing on (wood) pastures, tourism).

27861 Small-scale farming maintains biodiversity at its current level overall, but the intensification of land use (less
27862 abandoned fields) leads to a slight decline, particularly of farmland biodiversity. Farming practices rely on, and
27863 ensure a balance between nature's regulating and material contributions to people, while the level of non-
27864 material contributions, especially in relation to indigenous and local knowledge is preserved. People are relatively
27865 happy in spite of limited economic growth. Ethnic conflicts are settled and there are few inequalities. Community
27866 spirit is high and people are proud of the cultural and natural heritage of their landscape.

27867 **END OF BOX 5.10**

27868

27869 5.5.3 Policy instruments associated with pathways to sustainability

27870 The sets of actions and priorities in the pathways studies are supported by specific policy instruments.
27871 These have been analyzed using the following instrument categories in line with Chapter 6 and IPBES
27872 (2016d): (i) legal and regulatory instruments (e.g. laws); (ii) economic and financial instruments (e.g.
27873 taxes, subsidies); (iii) social and information-based instruments (e.g. education); and (iv) rights-based
27874 instruments and customary norms (e.g. strengthening collective rights).





27875 In the *green economy* pathways, legal and regulatory instruments are included in almost all studies
27876 (**Table 5.5**). These mostly involve the articulation and implementation of laws and regulations, but the
27877 setting of social and environmental standards and planning are also mentioned frequently. Legal and
27878 regulatory instruments are often combined with economic and financial instruments. An example of
27879 such a policy mix is the implementation of a regulation to deter illegal fishing accompanied by
27880 incentives for business models that embrace certification schemes and cooperative marketing in
27881 aquaculture (FAO, 2014). Another example is provided by Verkerk et al. (2016), where area protection
27882 is combined with incentives, e.g. payments for carbon sequestration and payments for recreation
27883 services.

27884 A similar reliance on a mix of economic and financial instruments with legal and regulatory instruments
27885 was found for Eastern Europe and Central Asia, where mainly national documents such as national
27886 biodiversity strategies and action plans and strategies for sustainable development were analyzed. For
27887 example, in Ukraine, an increase in pollution taxes as an economic instrument was combined with a
27888 revision of the permitted pollution thresholds in surface waters as a regulatory instrument (Parliament
27889 of Ukraine, 2016). In Belarus, including sustainable biodiversity use in spatial planning documents was
27890 suggested together with the introduction of payments for ecosystem services in financing nature
27891 conservation (Council of Ministers of the Republic of Belarus, 2015).

27892 Of similar importance to legal and regulatory instruments in *green economy* pathways, and again often
27893 mentioned as policy mixes, are social and information-based instruments. A wealth of instruments and
27894 tools are cited in the pathways related to the provision of information, e.g. via monitoring, valuation
27895 exercises and research. Environmental education and training are also important. For instance, the
27896 inclusion of "ecological trails" in tourist routes was proposed in Belarus (Council of Ministers of the
27897 Republic of Belarus, 2015). Participatory approaches are mentioned in a number of studies, but only a

few of these are from Eastern Europe and Central Asia. Least important in the *green economy* pathways are rights-based instruments and customary norms. Here, strengthening of rights and local rights is mentioned occasionally.

Table 5.5: Policy instrument categories related to narratives of pathways (Instruments mentioned: “+” = a few times, “++” = quite often, “+++” = very frequently, “no +” = not mentioned at all; n = number of pathways analyzed with respect to policy instruments).

Pathway narratives	Policy instrument categories related to pathway narratives			
	Legal & Regulatory 	Economic & Financial 	Social & information-based 	Rights-based & Customary 
Green economy (n=42)	+++	++	++	+
Low carbon transformation (n=6)	++	++	+	
Transition movements (n=16)	++	++	+++	+
Ecotopian solutions (n=4)	+++	+	++	

Low carbon transformation pathways were particularly vague concerning policy instruments (**Table 5.5**). Standards and targets are mentioned as legal and regulatory instruments, such as energy efficiency standards for all buildings combined with economic and financial instruments, such as energy taxation (WWF/Ecofys/OMA, 2011). Social and information-based instruments are almost exclusively associated with research and monitoring. As in the *green economy* pathways, rights-based instruments and customary norms played only a minor role.

The most important instruments in the *transition movements* pathways are social and information-based instruments (**Table 5.5**). These instruments focus on community actions, participatory processes, shared visions and voluntary agreements. Examples from the Europe and Central Asia pathways include changing individual consumption patterns towards sharing coupled with an animal welfare and rights perspectives, and the inclusion of ecological knowledge and criteria in decision-making (Kirveennummi et al., 2013). Rights-based instruments and customary norms are included in a few pathways, often in combination with social and information-based instruments. For example, in combination with increased participation, Palomo et al. (2011) highlight the importance of maintaining and including indigenous and local knowledge norms and customary rights perspectives to foster transformative capabilities and identity and conserve ecosystem qualities.

The importance of cross-scale integration and the mainstreaming targets related to of nature and its contributions to people into policymaking across a broad range of policy sectors, is also frequently considered in transition movement pathways in relation to social and information-based instruments. One pathway from the Food and Agriculture Organization of the United Nations suggests a combination of mainstreaming with other policy instruments for the governance of groundwater. In

this study, the implementation of legal, regulatory and institutional frameworks for groundwater that establish public guardianship and collective responsibility, permanent engagement of stakeholders and beneficial integration with other sectors is coupled with assessments, monitoring, up-to-date information and communication techniques, capacity building and incentive frameworks and investment programmes to foster sustainable, efficient groundwater use and adequate groundwater resources protection (FAO, 2015). Other studies, dealing with sustainability transitions additionally highlight rules safeguarding access to resources for vulnerable groups (Videira et al., 2014), trade barriers, and limits for energy use and CO₂ emissions (Capellán-Pérez et al., 2015; Grabs et al., 2016).

The few *ecotopian solutions* pathways all include legal and regulatory instruments, with planning playing a prominent role (Table 5.5). Of similar importance are social and information-based instruments, with the provision of information receiving substantial attention. Economic and financial instruments such as incentives are also important, whereas rights-based instruments are not reflected in the studies.

In general, the pathways analyzed refer to very different levels of implementation and almost no pathway indicates directly how an instrument is supposed to be developed and implemented in order to produce a certain outcome or impact on the state of nature or its contributions to people. While the instruments mentioned in most studies can be interpreted as policy mixes, little information is given concerning the order of implementation of the different instrument types involved in the mixes. In particular, most of the studies from Eastern European and Central Asia envision only short time horizons and the instruments mentioned might be perceived as initial steps towards improved environmental governance. Overall, most studies remained rather vague on specific policy instruments, allowing for only a superficial analysis. However, this analysis might still provide some useful insights into future policy options when considered in combination with the analysis of current policy instruments provided in Chapter 6, Section 6.6.1.

While there are differences between the pathway narratives, there are also similarities in the level of individual instruments and strategies to support these instruments. Investments, and more specifically ensuring conditions to foster environmentally friendly investments, play a role in all the narratives. The investments are meant to support the implementation of instruments, for example, the regulation of investments in the context of delivering consistent and transparent business regulations (e.g. WEF, 2010), but also in the context of fostering renewable energy production (e.g. Greenpeace, 2009), sustainable groundwater management (e.g. FAO, 2015) and food production (UNEP, 2012). Investments in research and development are also important across pathway narratives (e.g. ForestEurope, 2011; WWF/Ecofys/OMA, 2011).

The most prominent policy instrument described across all pathway narratives is the use of awareness-raising tools and education. Participation is also frequently mentioned, although the specificities and intensities of participation vary across the narratives, e.g. in *transition movements* or *ecotopian solutions* narratives, collaborative participation including the delegation of power and control by citizens is given preference over consultative forms of participation.

The pathways studies often rely on known policy instruments and tools (see a discussion of these tools in Chapter 6, Section 6.6.2), despite the future visions often being radical. Most of the pathways across the four narratives strongly rely on cross-scale integration, especially in terms of governance, with the exception of some *ecotopian solutions* pathways. The pathways mention a diversity of planning approaches and integrated impact assessment tools for achieving cross-scale integration (see discussions of such instruments and tools in Chapter 6, Section 6.6.3). Finally, while rights-based and customary norms instruments are neglected in most studies, other categories of instruments are frequently combined in policy mixes (see discussions on policy mixes in Chapter 6, Section 6.6.4).

27971

27972

5.5.4 Analysis of synergies and trade-offs within pathways

27973 The pathways for Europe and Central Asia involve alternative ways of mitigating trade-offs and
 27974 capitalizing on synergies. Trade-offs within individual pathways may occur when the expected impact
 27975 of actions within a pathway on nature, its contributions to people, and good quality of life compromise
 27976 a given contribution in favour of another; this could result from sectoral trade-offs and spatial trade-
 27977 offs. For example, several pathways focus on trade-offs and synergies between material contributions
 27978 (food, timber, fish, water) and water quality regulation, global climate regulation and nature
 27979 conservation. The four narratives propose different solutions for this: *green economy* and *low carbon*
 27980 *transformation* narratives focus on technological innovation or land planning from the regional
 27981 (Europe and Central Asia) to subregional scale; *ecotopian solutions* and to some degree *transition*
 27982 *movement* narratives concentrate on resolving trade-offs locally through changing demand for
 27983 nature's contributions to people, often along with innovation and multifunctional practices.

27984 Analysis of such trade-offs is challenging because of the qualitative nature of the pathways, many of
 27985 which were designed to guide the direction for action and change, rather than as comprehensive
 27986 analyses. Furthermore, the studies strongly emphasize the synergies between nature's material and
 27987 regulating nature's contributions to people afforded by the proposed pathways, but offer limited
 27988 analysis, even qualitatively, of resulting trade-offs. Finally, limited information was available regarding
 27989 non-material contributions (but see Brunner et al., 2015; Hanspach et al., 2014; Palacios-Agundez et
 27990 al., 2013; Palomo et al., 2011), risk mitigation (but see Brunner et al., 2015) or biotic regulation, such
 27991 as pollination, for which no explicit information was available.

27992 In the following we explore trade-offs within pathways first by summarizing the synergies and trade-
 27993 offs between different contributions from nature to people, or between nature and different
 27994 contributions found in the pathways studies. We then analyze trade-offs and synergies between the
 27995 four different pathway narratives by considering their links to the Sustainable Development Goals and
 27996 Aichi Biodiversity Targets.

27997

27998 5.5.4.1 Synergies and trade-offs between different contributions of nature to people and between 27999 nature and its contributions to people

28000 Several trade-offs could be identified within the specific sets of actions suggested by the individual
 28001 pathways. In general, management aimed at increasing nature's material contributions to people,
 28002 associated with fish-farming, forest harvest, biofuels and agricultural products as depicted in *green*
 28003 *economy* or *low carbon transformation* pathways implies an increase in land or water use or more
 28004 intensified production. In these pathways, increased production of food and other natural resources
 28005 might therefore imply a trade-off against alternative contributions from nature to people, and
 28006 biodiversity associated with semi-natural or protected sea- or landscapes. Conversely, promoting
 28007 nature conservation and some regulating contributions comes at a cost to production of food and
 28008 other natural resources, in particular in *transition movements* and *ecotopian solutions* pathways.
 28009 Nevertheless, some *transition movements* pathways promise to promote synergies between increased
 28010 quantity and quality of food, regulating contributions and nature protection through agro-ecological
 28011 practices based on combining indigenous and local knowledge and innovations.

28012 Overall, many critical trade-offs revealed in pathways studies concern food production: (i) competition
 28013 between food and biofuel (energy) production; (ii) trade-offs between food production and climate
 28014 regulation, water provision and quality, soil quality or biodiversity; and (iii) trade-offs between biofuel

(energy) production, soil quality and water provision and quality. In global level studies, such as the FAO (2014) vision, the two pathways on water and agriculture are argued to be so well integrated and in synergy that even the trade-off between water use for ecological functions and for food production is resolved, but this cannot be validated by the report itself.

Trade-offs with biodiversity are also mentioned with respect to energy infrastructure and forest products, while forest products themselves are cited as trading-off against water provision and soil quality. Lastly, trade-offs among components of nature associated with different ecosystems are also implicit in some pathways, especially in *regional multifunctionality* pathways that advocate land abandonment and rewilding at the expense of cultural biodiversity of extensively farmed areas (Pedroli et al., 2015; Prins et al., 2017; Sylvén & Widstrand, 2013). Even under *transition movements* pathways where land management relies on nature's contributions to people and synergies between nature and these contributions are fostered, some authors argue that tightly managing or engineering nature may ultimately not be ideal because it limits some natural processes (e.g. species dispersal and gene flow) (Heikkinen et al., 2012). Thus, the studied pathways only partly succeed in mitigating the critical trade-offs around food, water, nature and climate, which they aim to resolve.

5.5.4.2 Relating pathways to the Aichi Biodiversity Targets

As outlined in Section 5.4, the Europe and Central Asia visions prioritize Aichi Biodiversity Targets 4 and 7. The actions within the different pathways targeting nature, its contributions to people, and good quality of life were examined to assess how they address the different strategic goals of the Strategic Plan for Biodiversity 2011-2020 (although not necessarily in line with their timeframe of 2020) (electronic Appendix 5.2). Insufficient evidence was available to undertake a reliable analysis of specific Aichi Biodiversity Targets due to uncertainties regarding the information on the pathways about specific actions, especially regarding indirect drivers.

Overall, targets within Strategic Goal A to address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society are covered weakly across all pathway narratives. Strategic Goal E to enhance implementation through participatory planning, knowledge management and capacity building is also poorly covered. Here, only the *transition movements* pathways offered sets of actions to change resource-intensive life styles, and foster education, good social relations and equity, for instance in urban or rural settings (see Section 5.5.2 for further details on the actions).

Consistent with the focus of the pathways on direct drivers, Strategic Goal B to reduce direct pressures on biodiversity and promote sustainable use and, more specifically, Target 7 (sustainable management of agriculture, aquaculture and forestry) is addressed by all pathways except for the *low carbon transformation* – innovation pathway, through their land planning and land management actions, for instance, targeting multifunctionality and biodiversity conservation either at local or regional scales. A similarly good coverage is found for Strategic Goal D to enhance the benefits to all from biodiversity and ecosystem services as nearly all pathways include actions targeting at least some of nature's contributions to people. Coverage of Strategic Goal C on the improvement of the status of biodiversity by safeguarding ecosystems, species and genetic diversity was mixed.

5.5.4.3 Relating pathways to the Sustainable Development Goals

Synergies and trade-offs within pathways were also assessed in terms of the Sustainable Development Goals. Here, we analyzed how the intended sets of actions within pathways could be helpful in

achieving particular Sustainable Development Goals (although not necessarily in line with their timeframe of 2030). This involved using the expert opinion of the author team to combine information on how different indicators of nature, its contributions to people, and good quality of life relate to the Sustainable Development Goals, and how these indicators are likely to be affected by the actions in the pathways and the predominant dimensions of sustainability represented by each Sustainable Development Goal: biophysical (Goals 6, 13, 14, 15), economic (Goals 8, 9, 10, 12) and social (Goals 1, 2, 3, 4, 5, 7, 11, 16) (**Figure 5.20**).

Of the Sustainable Development Goals which were found to be prominent across visions for Europe and Central Asia (Section 5.1.2) the majority, that is Goals 13 (climate), 15 (life on land), 11 (sustainable cities) and 12 (responsible production and consumption), are addressed significantly by at least half of the pathways, and even by all of them in the case of Goal 15. Therefore, when aiming to achieve goals 11, 12, 13 and 15 different sets of actions from diverse pathways could be employed. In particular, multifunctionality based on the combination of traditional and innovative practices in agriculture and forest management is critical for achieving these goals, but can be operationalized at different scales depending on pathways, and across different regions of Europe and Central Asia.

However, the focus on the biophysical dimension associated with Goals 13 and 15 in some pathways, for example, in the *green economy* narrative, can come at a cost of ignoring other goals associated with the economic and social dimensions of sustainability, such as Goal 7 (clean energy), and especially Goals 8 (decent work) and 9 (industry and infrastructure). These were highlighted as important in the Europe and Central Asia visions, but are hardly addressed across pathways with the notable exception of *transition movements* pathways for Goals 8 and 9.

Low carbon transformation or *ecotopian solutions* pathways with a focus on innovation address biophysical objectives less strongly than other pathways, particularly for Goal 15 (except ecotopian solution - *local multifunctionality*). There are also few actions associated with Goal 13 for *ecotopian solutions* pathways. In contrast, transition movement pathways address all of the Sustainable Development Goals identified as being important in the Europe and Central Asia visions, except Goal 7, because they offer the broadest set of actions targeting elements of nature, multiple contributions from nature to people, (material, regulating and non-material) and multiple dimensions of a good quality of life.

Figure 5.20: Estimated ability of the pathway narratives to achieve the Sustainable Development Goals shown in three groups (A, B, C). For each pathway, the plot represents the relative score for each Goal according to actions on nature, its contributions to people, and good quality of life. Pathways are *green economy* (GE), *low carbon transformation* (Low C), *ecotopian solutions* (ET) and *transition movements* (TM). Sustainable Development Goals are clustered and coloured according to their predominant character: biophysical, economic, social dimensions of sustainability (Folke et al., 2016); global partnership refers to Goal 17. The size of the bar towards each Goal shows the trends of actions within each pathway towards indicators of nature, its contributions to people, and good quality of life associated with that Goal, ranging from 0 (not mentioned) to 1 (increasing for all indicators). Note the pathways often concern timescales beyond 2030.





Based on this analysis, the ability of the pathway narratives to address the Sustainable Development Goals was divided into three groups in terms of their representation of dimensions of sustainability as follows:

- First, the three *green economy* pathways and the *ecotopian solutions - local multifunctionality* pathway have a strong focus on the biophysical dimension, along with some on the social dimension, but fewer on the economic dimension. Within this group, the focus on the economic dimension is more developed in the *green economy – innovation* pathway, while it is absent in the *green economy – land sparing* pathway, and solely focused on Goal 12 (responsible production and consumption) in the *green economy – land sharing* and the *ecotopian solutions - local multifunctionality* pathways (**Figure 5.20A**).
- Second, pathways focusing primarily on climate action including the two *low carbon transformation* pathways and the *ecotopian solutions - innovation pathway* have a weaker focus on the biophysical dimension, but address the social dimension more than the first group. In particular, they include actions targeting Goals 2 (food) and 11 (sustainable cities and communities), along with a strong focus on Goal 12 (responsible production and consumption) for the economic dimension (**Figure 5.20B**).
- Third, the two *transition movements* pathways promise to address the greatest diversity of Sustainable Development Goals and thus cover biophysical, social and economic dimensions.

28120 As such, they best fulfil the three dimensions of sustainability articulated in visions for Europe
28121 and Central Asia (**Figure 5.20C**).

28122 The analysis shows that the four pathway narratives lead to different trade-offs and synergies between
28123 Sustainable Development Goals and associated dimensions of sustainability. Nevertheless, a recurring
28124 trade-off was found between food provision and nature conservation goals on the one hand and some
28125 important social and economic goals on the other hand. This trade-off seems to be difficult to mitigate
28126 across all the pathways. More specifically, based on the actions they reported, none of the pathway
28127 narratives could fully resolve the major trade-off between Goals 2 (food), 14 (oceans) and 15 (land)
28128 with Goals 7 (clean energy), 9 (industry and infrastructure), 10 (equity), 16 (justice) and 17 (global
28129 responsibility). Interestingly, the ability to achieve Goal 12 was found to vary independently of this
28130 trade-off, suggesting that pathways towards responsible production and consumption can be
28131 considered in combination with either the first (2, 14 and 15) or the second (7, 9, 10, 16 and 17) sets
28132 of goals.

28133 Overall, *transition movements* pathways appear to be the most promising in achieving a wide range of
28134 Sustainable Development Goals and addressing trade-offs across biophysical, social and economic
28135 dimensions of sustainability. However, the actual effectiveness of the actions proposed by the
28136 different pathways in mitigating negative impacts and promoting positive impacts would need support
28137 from scenario and modelling studies (see next section and examples in **Box 5.11** and (Kubiszewski et
28138 al., 2017) described in Section 5.3.4).

28139

28140 **Box 5.11: Assessing the impact of pathways using an integrated assessment model**

28141 Models can be applied to pathways to simulate the potential impacts resulting from their proposed actions, for
28142 example on biodiversity conservation, or trade-offs between nature and its contributions to people. Such
28143 information is needed to compare alternative pathways and to inform decision-making. A study by the
28144 Netherlands Environmental Assessment Agency (2012) assessed the impacts of three alternative pathways on
28145 global biodiversity, analyzing the extent to which the pathways help to meet the 2050 Vision of the Strategic Plan
28146 for Biodiversity 2011-2020. The different pathways (consisting of combinations of biophysical and behavioural
28147 options) were designed to step-up and scale-up efforts within activity sectors towards biodiversity-friendly
28148 production. They included:

- 28149 • A *global technology* pathway, which in line with the *green economy* – innovation narrative relies on
28150 large-scale technologically-optimal solutions and a high level of international coordination;
- 28151 • A *decentralized solutions* pathway, which in line with the *green economy* – *land sharing* narrative
28152 focuses on regional solutions; and
- 28153 • A *consumption change* pathway, which in line with the *transition movements* – *resource sparing*
28154 narrative prioritizes changes in human consumption patterns.

28155 Model results show that the actions within the three pathways are able to prevent more than half of the loss of
28156 biodiversity that is projected to take place worldwide in the coming 35 years (**Figure 5.21**).

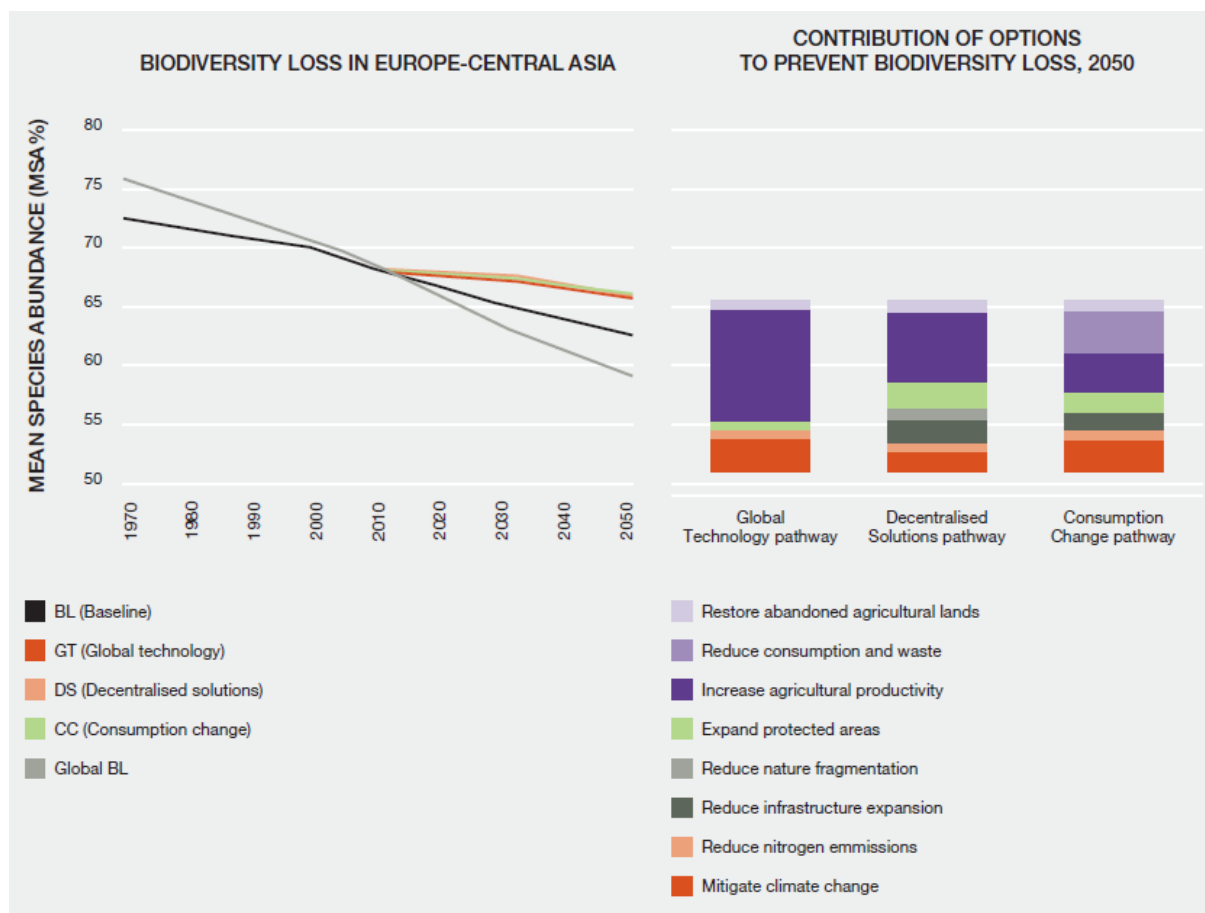
28157 The results highlight the importance of mainstreaming policy objectives concerning biodiversity across sectors
28158 and the need to take account of synergies and trade-offs between nature's contributions to people, in planning
28159 long-term solutions that lead to a halt in biodiversity loss while maintaining multiple contributions. For example,
28160 the agricultural sector was identified in all pathways as playing a critical role in contributing to biodiversity loss
28161 in forests, water bodies and coastal ecosystems. Increased use of bioenergy or hydropower resulting from
28162 climate change mitigation and adaptation policies may reduce the impacts of climate change on biodiversity in
28163 the coming decades, but is also projected to cause an expansion of agricultural lands and increased river
28164 fragmentation, which would in turn have detrimental impacts on biodiversity (Netherlands Environmental
28165 Assessment Agency, 2012).

28166 A further multi-model and expert assessment was carried out by Prins et al. (2017) for four pathways for the
 28167 European Union plus Switzerland (28 countries) (van Zeijts et al., 2017). These four pathways included:

- 28168 • *Strengthening cultural identity*, closest to the *transition movements – resource sparing* pathway;
- 28169 • *Allowing nature to find its way*, illustrating a *green economy – land sparing* pathway incorporating
 28170 rewilding;
- 28171 • *Going with the economic flow*, another *green economy – land sparing* pathway with a strong liberal
 28172 component and elements of innovation; and
- 28173 • *Working with nature*, a *green economy – land sharing* pathway, proposed as a possible means to bridge
 28174 with and upscale *transition movements* pathways.

28175 The analysis showed that some of the actions are fully compatible across pathways, particularly those associated
 28176 with the conservation of cultural landscapes and the use of nature's regulating contributions to people in
 28177 agriculture, which were included in strengthening cultural identity, allowing nature to find its way and working
 28178 with nature. Conversely, some interventions were incompatible across pathways, such as the establishment of
 28179 large dynamic nature areas in allowing nature to find its way with the *land sharing* approach of strengthening
 28180 cultural identity and working with nature.

28181 Nevertheless, some combinations of actions could lead to synergies given careful management. For example,
 28182 agricultural abandonment of less productive land under going with the economic flow would provide the large
 28183 nature areas envisioned in allowing nature to find its way, potentially resulting in a significant nature protection
 28184 network given top-down planning and regulation. As another example, the private parks favoured in going with
 28185 the economic flow could support cultural landscapes for strengthening cultural identity given negotiation on
 28186 access and citizen participation. Overall, the exploration of these combinations using modelling and expert
 28187 assessment highlighted how pathways reflecting different worldviews and objectives may be complementary
 28188 across Europe and Central Asia.



28189

Figure 5.21: Ability of actions within three pathways (GT - *global technology*, DS - *decentralized solutions* and CC - *consumption change*) to prevent biodiversity loss in 2050 (as represented by mean species abundance) compared to a scenario of continuing trends (BL = baseline in Europe and Central Asia); Global BL = baseline for the globe and is included for comparison with the regional results for Europe and Central Asia. Source: Netherlands Environmental Assessment Agency (2012).

END OF BOX 5.11

5.5.5 Linking pathways to exploratory scenarios

An alternative method for assessing trade-offs within pathways is to link the pathways to one of the scenario archetypes introduced in Section 5.2, based on similar features in terms of the types of policy and management actions they represent. This allows the synthesis of results from the impact assessment in Section 5.3 with the findings from the pathways by assessing the expected consequences of pathway actions on nature, its contributions to people, and a good quality of life. The synthesis is based on 15 pathways studies, which also used exploratory scenarios. Information from these 15 pathways studies was used to assign scenario archetypes to the four groups of pathway narratives.

The pathway narratives tended to be consistently associated with certain scenario archetypes. Overall, *innovation* or *land sparing* pathways from *low carbon transformation* and *green economy* narratives were associated with the *global sustainable development* scenario archetype (with a focus on behavioural and technological change or strong governments, see Section 5.3.3.5). Meanwhile, with few exceptions (Brunner et al., 2015; Mont et al., 2014), *green economy land sharing*, *transition movements* or *ecotopian solutions* pathways were associated with the *regional sustainability* scenario archetype, with a strong predominance of collaborative solutions (see Section 5.3.3.4).

Impacts on nature, its contributions to people, and a good quality of life under the *global sustainable development* scenario archetype from Section 5.3.3.5 (and **Figure 5.10**) can be summarized as largely positive for all indicators of nature, its contributions to people, and quality of life. More specifically, nature indicators are projected to improve in all regions of Europe and Central Asia, except for some studies in southern and Alpine parts of Western Europe. In terms of nature's contributions to people, regulating (e.g. climate regulation, air quality regulation, erosion control and soil fertility) and material contributions (e.g. food and timber) are mainly projected to be enhanced, although negative impacts due to water stress may be experienced in southern parts of Western and Central Europe and in Central Asia. Similarly, most quality of life indicators improve, with the exception of traditional knowledge and local identity due to the global nature of this scenario archetype and the focus of actions on top-down regulatory instruments.

The *regional sustainability* scenario archetype is associated with similarly positive overall impacts for indicators of nature's contributions to people and quality of life, but impacts on nature are unclear with some studies showing improvements and others declines in biodiversity vulnerability. This may be because fewer modelling studies were found for this scenario archetype, with no studies from Central Asia. More specifically, all regulating contributions and quality of life indicators included in modelling studies showed improvements. Results for material contributions were more variable, with increases in forests/timber production and bioenergy, but mixed impacts for food production depending on the region and study.

To summarize, both scenario archetypes perform well in their likely achievement of many of the Aichi Biodiversity Targets and Sustainable Development Goals (Section 5.3.4; **Figure 5.15**). *Global sustainable development* (and hence the linked pathways of *green economy* and *low carbon transformation*) provide more consistent improvements in nature's material contributions to people, alongside regulating contributions, while *regional sustainability* (and hence the linked pathways of *transition movements*, *ecotopian solutions* and *green economy land sharing*) provide more consistent improvement in quality of life indicators alongside regulating contributions, but sometimes through actions which result in lower material contributions.

5.5.6 Addressing trade-offs by mainstreaming and cross-scale integration

As discussed in Chapter 6, 20% of land- and seascapes are currently protected. Mainstreaming nature and its contributions to people across all sectors in private and public decision-making on the remaining 80% of land- and seascapes appears as one of the most important issues in the future (see also Bouwma et al., 2017; Schleyer et al., 2015). A need for mainstreaming was implicitly suggested by the pathways studies, as they were often developed for a single sector with a focus on a given narrative. Several alternative pathways often exist for the same sector. For example, for food and agriculture in Western, Central and Eastern Europe, three pathways were identified: *green economy* innovation narrative (European Commission, 2015), *green economy subregional land sharing* narrative (Food Drink Europe, 2012), and *transition movements* narrative (Barabanova et al., 2015).

Likewise, *green economy* pathways for forestry at the scale of Western, Central and Eastern Europe may either be based primarily on innovation (Forest Europe, 2011) or on *subregional multifunctionality* (Forest Europe, 2011). The transition to sustainability of the water sector, a sector particularly critical for the Mediterranean or Eastern Europe and Central Asia, is also addressed by either global narratives of *green economy* with technical and governance innovation (Cosgrove & Rijsberman, 2014; UNESCO, 2015) or by a European *transition movements* narrative also relying on technical and governance innovation (van Vliet & Kok, 2015). Here, "Europe" refers to "Greater Europe reaching to the Caucasus and Ural Mountains, and including the Mediterranean rim countries of North Africa and the Near East".

A diversity of options from different pathways is seen as an asset for adaptation and sustainability transition (Wise et al., 2014). Considering several alternative scenarios, which effectively represent alternative pathways to sustainability and specific Sustainable Development Goals, is considered essential for designing policy at the regional scale that considers alternatives depending on specific nations or biogeographic areas and on prevailing societal choices (Prins et al., 2017).

For Western and Central Europe, the three alternative cross-sectoral pathways of the VOLANTE project (Brown et al., 2016; Pedrolí et al., 2015) illustrate trade-offs across *green economy land sparing* and *subregional land sharing* pathways, and a third ecotopian *local multifunctionality* narrative. For the food production sector, Barabanova et al. (2015) offer insights into policy and social trade-offs between a *green economy* narrative of technical innovation and a *transition movements* narrative of changed food and dietary patterns for implementing organic agriculture in the European Union. In particular, only the *transition movements* pathway fosters the integration of knowledge from different social and ethnic groups. As a local example, (Palomo et al., 2011) also contrasted a *green economy* narrative of technical innovation with a *transition movements* narrative of transition capabilities in Spain. Both pathways enabled the reconciliation of food production, water management and tourism, but with contrasting approaches to whole landscape management (the protected area and the land surrounding it) and to the education and empowerment of local people.

28277 Pathways may not need to be alternative, but could instead be sequenced over time. In sustainability
 28278 transitions studies (Frantzeskaki et al., 2012; Rotmans et al., 2001), pathways usually start with
 28279 incremental and often non-disruptive actions in the short-term, often tuned to adaptation rather than
 28280 mitigation or transformation, such as those depicted in *green economy* and *low carbon transformation*
 28281 narratives. These short-term actions do not challenge current worldviews or institutions but pave the
 28282 way and condition the implementation of more radical, disruptive actions in the medium- and long-
 28283 term (Butler et al., 2014; Fazey et al., 2015; Wise et al., 2014), such as those imagined in *transition*
 28284 *movements* or *ecotopian solutions* narratives, and in visions of social transformations towards
 28285 sustainability. This view is also consistent with the concept of “seeds” of transformation, where early
 28286 local transformation may later be scaled-up to regions and globally (Bennett et al., 2016).

28287 Many of the trade-offs highlighted by this analysis straddle across socio-economic sectors. Cross-
 28288 sectoral mainstreaming and cross-scale integration is seen as a means to mitigate trade-offs within
 28289 pathways and across scales. Across the different regions of Europe and Central Asia, the overwhelming
 28290 majority of pathways referred to at least potential, cross-sectoral interactions, irrespective of their
 28291 initial sectoral focus. The concept of the food-water-energy nexus, that is the multiple interactions
 28292 (synergies and trade-offs) between food, water and energy provisioning, demand and access, and their
 28293 environmental and social determinants, is core to many pathways. Other critical cross-sectoral
 28294 interactions concern integration across productive land uses, tourism, education, planning and nature
 28295 conservation, or the consideration of how human activities affect freshwater and coastal waters. A
 28296 specific idea found in the context of innovation pathways for the *green economy* narrative, is the
 28297 notion of bioeconomy landscapes, which rely on cross-sectoral networks of scientific, technological
 28298 and managerial excellence (van Zeijts et al., 2017). Pathways within the *transition movements* narrative
 28299 focus particularly strongly on the integration of multiple dimensions of governance, technology,
 28300 economy and society. In addition to these cross-sectoral interactions within individual pathways, there
 28301 is great scope for mainstreaming (not just interactions) by, in future steps, integrating pathways
 28302 formulated for different sectors.

28303 Likewise, cross-scale integration, whether across adjacent scales, or across the whole range of scales
 28304 from local to subnational, national, regional and in some instances to global (e.g. for energy / climate
 28305 or food systems), is a strong common feature of most proposed sustainability pathways, with the
 28306 exception of some *ecotopian solutions*. Verkerk et al. (2016) found that, under the available policy
 28307 options and modelling constraints, *local multifunctionality* was not feasible across the whole of the
 28308 European Union, even if successful for some areas due to spatial trade-offs and spill-over effects, as
 28309 highlighted in Section 5.5.2. In contrast, *transition movements* pathways aim at integration with larger
 28310 scales, especially in terms of governance. For example, the global Greenpeace (2009) pathway includes
 28311 both actions at the local scale (use of agroecology) and actions at the larger scale (protection of areas
 28312 with high conservation value – globally and regionally), thus combining *land sharing* and *land sparing*
 28313 approaches in a *transition movements* narrative. While mainstreaming from local “green pioneers”
 28314 solutions to a green society as a whole remains a great challenge, pathways for such spatial integration
 28315 (scaling-up) are now starting to be imagined (van Zeijts et al., 2017). Bennett et al. (2016) suggest in
 28316 particular to use combinations of exemplary transition movement “seeds” in large-scale (e.g. global)
 28317 scenarios, as well as in local participatory scenarios.
 28318

5.6 Conclusions

5.6.1 Overall synthesis

Chapter 5 focuses on the future interdependencies between nature and society. It asks to what extent findings from reviewed literature can establish future interactions between indirect drivers (such as human population change, economic or foreign policy), direct drivers (such as land use patterns or climate change), nature, its contributions to people, and a good quality of life. Each of these interactions represents a complex set of interrelationships. Scenarios and models are useful tools for advancing understanding of these interrelationships and how they might change in the future.

Four linked assessments on exploratory scenarios, integrated assessment models, visions of sustainable development, and pathways or normative scenarios for achieving such visions were undertaken to better comprehend what might happen to nature, its contributions to people, and a good quality of life in the future, and the actions decision-makers can take to move away from undesirable futures towards more sustainable futures.

The assessment of exploratory scenarios revealed that existing scenario studies for Europe and Central Asia can be categorized into six broad scenario archetypes, which describe different plausible futures for the region:

- *Business-as-usual* assumes that the future will be characterized by a continuation of past and current trends in indirect and direct drivers.
- *Economic optimism* assumes that global developments are steered by economic growth resulting in a strong dominance of international markets with a small degree of regulation. Environmental problems are only dealt with when solutions are of economic interest.
- *Regional competition* assumes an increasingly fragmented world with a growing gap between rich and poor, and increasing problems with crime, violence and terrorism. This leads to a strong focus on national or regional security, increased trade and other barriers to cooperation, and often low concern for the environment.
- *Regional sustainability* assumes a shift towards local and regional decision-making, which is strongly influenced by environmentally aware citizens. A proactive attitude to environmental management prevails, but poor international collaboration obstructs coordination to solve global environmental issues.
- *Global sustainable development* assumes a globalized world with an increasingly proactive attitude of policymakers and the public at large towards environmental issues, which are dealt with using a high level of top-down regulation.
- *Inequality* assumes fundamental and growing economic, political and social inequalities with power becoming concentrated in a relatively small political and business elite that takes environmental responsibility, while keeping the large lower-class poor, but satisfied.

Impacts on nature, its contributions to people, and a good quality of life within each of these plausible futures, as simulated by integrated assessment models, are summarized in **Table 5.6**. This provides a broad indication of whether impacts, on average, are positive, negative or mixed. More positive impacts are projected under futures that assume proactive decision-making on environmental issues, such as the *global sustainable development* and *regional sustainability* scenario archetypes, than those that are reactive, such as *economic optimism*, *regional competition* and *business-as-usual*. The two *sustainability* scenario archetypes also promote a more holistic approach to managing human and environmental systems, which supports multifunctionality and multiple contributions from nature to

people. Alternatively, the *economic optimism* scenario archetype tends to promote a more limited number of services, particularly material contributions such as agricultural and timber production resulting in strong positive effects in market values and negative effects in non-market values. Such scenarios are often associated with trade-offs between increases in food provision (generally associated with the expansion of agricultural land or the intensification of livestock production and fish captures) and decreases in the provision of regulating contributions (e.g. prevention of soil erosion, regulation of water quality and quantity) and nature values. Similar trade-offs were also identified between increases in timber provision and decreases in regulating (e.g. carbon sequestration) and non-material contributions (e.g. aesthetic value).

Trade-offs were also apparent under the sustainability scenario archetypes, particularly under *regional sustainability*, where society chooses to live less resource-intensive lifestyles and hence nature's material contributions to people, tend to decrease, while nature and regulating contributions increase. Most of the trade-offs projected in the sustainability scenarios relate to the use of land and water. These included: (i) agricultural extensification leading to increases in agricultural areas and consequent decreases in other land uses, such as forests, to maintain food production levels and not to create displacement effects to other regions; (ii) expansion of bioenergy croplands at the expense of food production or biodiversity-rich forests; (iii) and reforestation or afforestation to improve climate regulation or natural hazard regulation resulting in reductions in surface water resources, leading to water stress and potentially detrimental effects on aquatic ecosystems (although it is also recognized that in some circumstances reforestation can lead to improved water resources). In tackling such trade-offs to develop sustainable land and water management strategies, cooperation between sectors and countries to foster strategic planning was considered crucial, as characterized as part of the *global sustainable development* scenario archetype.

Table 5.6: Traffic light summary of projected impacts on nature, its contributions to people, and good quality of life indicators (green = positive, red = negative, amber = mixed). Note: interpretation is based on the detailed description of model results in Section 5.3.3. Only two studies are available for the inequality scenario archetype, so results are highly uncertain and missing for non-material contributions and good quality of life indicators.

Scenario archetype	Nature	Nature's contributions to people			Good quality of life
		Regulating	Material	Non-material	
Business-as-usual					
Economic optimism					
Regional competition					
Regional sustainability					
Global sustainable development					
Inequality					

28391 Interpretation of these broad findings for decision-making should bear in mind that scenario and
 28392 modelling studies are projections of the future and involve different sources of uncertainties. These
 28393 include uncertainties arising from scenario assumptions, model structure, model inputs and the
 28394 propagation of uncertainties across the integrated components of the systems, amongst others.

28395 The reviews of visions and pathways of sustainable development aimed to synthesize knowledge on
 28396 the actions decision-makers can take to move away from undesirable futures, such as *regional*
 28397 *competition*, towards more sustainable futures, such as *regional sustainability*. Many visions, and the
 28398 pathways to achieve them, have been developed for policy support and can be linked to the
 28399 Millennium Development Goals, Sustainable Development Goals or Aichi Biodiversity Targets.
 28400 However, the Sustainable Development Goals tend to be more consistently covered, relative to the
 28401 Aichi Biodiversity Targets, suggesting that the strong focus on elements of good quality of life in visions
 28402 is not sufficiently supported by goals related to the nature and ecosystems that underpin nature's
 28403 contributions to people and a good quality of life. This implies a need to further mainstream
 28404 biodiversity in its various dimensions into strategic planning and decision-making.

28405 Multiple pathways were found at global, regional and local scales that offer the means to devise
 28406 courses of actions towards visions of sustainable development. The pathways could be grouped into
 28407 four distinctive sustainability narratives: *green economy*, *low carbon transformation*, *transition*
 28408 *movements* and *ecotopian solutions*. The *green economy* and *low carbon transformation* narratives,
 28409 which dominate at global and regional scales, build towards sustainability without challenging the
 28410 economic growth paradigm. They share three alternative pathways: *technological innovation*, *land*
 28411 *sparing* with strong nature protection in designated areas, or *land sharing* with lower use intensity and
 28412 diversification of production of nature's contributions to people. Combinations of top-down legal and
 28413 regulatory instruments mixed with economic and financial instruments designed at regional (European
 28414 Union) or national levels (Eastern Europe and Central Asia) are essential to support pathways of *green*
 28415 *economy* and *low carbon transformation*. Such pathways are often formulated at a sectoral level, and
 28416 integration across sectoral pathways is critical. However, because *green economy* and *low carbon*
 28417 *transformation* pathways do not fully mitigate trade-offs between production activities and the
 28418 conservation of nature and regulating and non-material contributions, as well as with important
 28419 aspects of good quality of life, such as equity and indigenous and local knowledge, they may not be
 28420 sufficient alone to achieve sustainability.

28421 Instead, they may pave the way for the first steps of *transition movements* pathways towards future
 28422 transformation to meet ambitious goals for nature and its contributions to people, to support better
 28423 quality of life. At the same time, nurturing of diverse local, bottom-up *transition movements* or
 28424 *ecotopian solutions* pathways is suggested. Such pathways reconsider fundamental values and
 28425 lifestyles through sets of actions focusing on less resource intensive lifestyles, education, good social
 28426 relations and equity (e.g. food and dietary patterns, transport, energy and consumption patterns).
 28427 *Transition movements* pathways also develop bottom-up transformative capabilities by combining
 28428 rights-based instruments and customary norms (including indigenous and local knowledge) and social
 28429 and cultural instruments. So far, innovative thinking for bridging scientifically and institutionally from
 28430 these local, bottom-up and sectoral options, to systemic, regional and global solutions remains limited.
 28431 The incorporation of combinations of exemplary transition pathways into large-scale scenario
 28432 exercises and into participatory scenario development has been suggested as a way forward.

28433 The last step in this synthesis section presents a combined analysis of the results from the scenario
 28434 archetypes and pathways assessments. The extent to which policy goals and targets, such as the
 28435 Sustainable Development Goals and Aichi Biodiversity Targets, are likely to be achieved under the
 28436 different scenario archetypes, and the extent to which the pathway narratives are likely to influence

the achievement of the Sustainable Development Goals (although not necessarily in line with their timeframe of 2030) is summarized in **Table 5.7**. *Regional competition* is estimated to lead to failure in the majority of the targets. *Economic optimism* is estimated to have a mixed level of success in achieving the Sustainable Development Goals, but fails to achieve the majority of the Aichi Biodiversity Targets, while *business-as-usual* shows the opposite effect. These scenarios focus on instrumental values and individualistic perspectives, with a more limited acknowledgement of relational or intrinsic values, and hence are unlikely to offer effective sustainable solutions. Alternatively, *regional sustainability* and *global sustainable development* are estimated to achieve the majority of Sustainable Development Goals and Aichi Biodiversity Targets due to their focus on value diversity across multiple contributions from nature to people, and aspects of a good quality of life.

Transition movement pathways address all of the Sustainable Development Goals identified as being important in the Europe and Central Asia visions (Section 5.1.2 and 5.5.4), except one, because they offer the broadest set of actions targeting elements of nature, multiple contributions from nature to people (material, regulating and non-material) and multiple dimensions of a good quality of life. The other pathways include actions that focus on specific Sustainable Development Goals more than others. For example, the *green economy – land sharing* and the *ecotopian solutions – local multifunctionality* pathways have a strong focus on nature and intrinsic values, the *green economy – innovation* pathway has a greater focus on instrumental values, while the two *low carbon transformation* pathways and the *ecotopian solutions – innovation* pathway have a weaker focus on intrinsic values, but address relational values to a greater extent than other pathways (albeit with a similar level to the *transition movements* pathways).

In summary, the different pathway narratives offer alternative sets of actions for decision-makers (see Section 5.5.2) that can be tailored according to regional needs and societal preferences. The pathways are non-exclusive and the actions within them can be sequenced over time to address environmental and social challenges, including cross-sector and cross-scale interactions and trade-offs, and to move society towards a sustainable future. Chapter 6, and more specifically Section 6.6, provides further detailed information on policy options to realize the sustainable futures laid out in Chapter 5.

Table 5.7: Traffic light summary of the estimated extent to which the Aichi Biodiversity Targets (ABTs) and Sustainable Development Goals (SDGs) are likely to be met under the six scenario archetypes for Europe and Central Asia (based on Section 5.3.4), and the relative effect of the actions in the pathway narratives on helping to reach the Goals (based on Section 5.5.4). Left: red = widespread failure of policy targets; green = widespread achievement of targets; amber = mixed achievement of targets. Right: darker shades of green indicate a greater degree of influence of actions within pathways on achieving the Sustainable Development Goals (note that here all three dimensions of sustainability, biophysical, economic and social are given equal weights, i.e. the balance across dimensions addressed in Section 5.5.4.3 is not considered). Linkages between the scenario archetypes and pathway narratives are indicated through colour coding of text (see Section 5.5.5). Note: the scenarios and pathways concern different time frames to the Aichi Biodiversity Targets and Sustainable Development Goals.



5.6.2 Knowledge gaps and uncertainties

In this section, the knowledge gaps and uncertainties that appeared across all the sections of Chapter 5 are first listed followed by knowledge gaps specific to the assessments undertaken within each section.

Knowledge gaps and uncertainties across all sections of the chapter:

- The assessment of how findings from the different reviews related to policy goals or targets similar to the Sustainable Development Goals and Aichi Biodiversity Targets was mostly based on the expert judgement of the author team, as most documents reviewed did not explicitly include links to these goals or targets. The absence of direct links to these international goals in reviewed documents is related, on the one hand, to the fact that scenarios usually deal with time horizons going beyond 2020 and even 2030. Furthermore, most studies were published before the Sustainable Development Goals were adopted and naturally did not include the goals. Moreover, the partial coverage of the full set of these international goals is related to their regional prioritization and reflects the dominant regional values. Lastly, our primary focus on studies targeting at least nature and its contributions to people meant that other strategic documents focusing on good quality of life with only loose links to nature were not considered.

- 28494 • All reviews reveal knowledge and information gaps for Central Asia and, to a lesser extent, for
28495 Eastern Europe. In general, higher uncertainties in outcomes are expected from regions where
28496 evidence is based on very few studies. There is a high diversity in the complexity and degree
28497 of integration reflected in the four reviews, which is explored further below.
- 28498 • Studies which explicitly covered indigenous and local knowledge were largely unrepresented
28499 in all the reviews. This is related to the focus of some of the reviews on the national scale or
28500 higher. Yet, while indigenous and local knowledge was often not included explicitly, a range of
28501 studies, particularly in the visions and pathways review, were developed together with
28502 stakeholders and revealed valuable insights into nature's non-material contributions to people
28503 and relational values. This confirms the suggestion made by the IPBES "Guide on the
28504 production and integration of assessments from and across all scales" (IPBES/4/INF/9) as well
28505 as in the IPBES Methodological Assessment of Scenarios and Models of Biodiversity and
28506 Ecosystem Services (IPBES, 2016c), where participatory scenario development and modelling
28507 are recommended as powerful approaches for knowledge co-production and the inclusion of
28508 indigenous and local knowledge. The development of new scenarios for IPBES (Rosa et al.,
28509 2017) will open up opportunities for such approaches and work towards the appropriate
28510 inclusion of indigenous and local knowledge in future assessments.
- 28511 • The coverage of nature's non-material contributions to people, and quality of life indicators
28512 was poor in most scenario and modelling studies and they were absent from, or limited to,
28513 recreational benefits in most visions and pathways studies.
- 28514 • Studies covering the marine realm were poorly represented, and almost absent from visions
28515 and pathways. Consequently, very few results and conclusions on associated ecosystems can
28516 be provided.
- 28517 • The analysis of how values were included in the exploratory scenario and normative scenario
28518 (or pathways) literature showed that some dimensions of value (i.e. intrinsic values) were not
28519 considered by the majority of futures studies. This highlights a significant gap in the current
28520 literature in recognizing the diversity of values where most studies predominantly focus on
28521 anthropocentric values (i.e. instrumental). Furthermore, socio-cultural approaches to
28522 valuation were used to a much lesser extent than biophysical or economic methods.

28523 In the following, knowledge gaps and uncertainties for each of the individual reviews are highlighted:

28524 The review on exploratory scenarios revealed that the indirect drivers of institutional change, cultural
28525 change and technology were rarely explicitly included within scenario analyses, but frequently
28526 subsumed within common socio-economic storylines (i.e. IPCC SRES, SSPs). Only limited aspects of
28527 these driver categories were addressed by the studies, for example efficiency of governance, level of
28528 international collaboration and proactivity of environmental management among institutional drivers;
28529 diet, material and meat consumption and environmental awareness among cultural drivers; and
28530 agricultural efficiency among technological drivers. Given the frequent presence of technology,
28531 cultural and governance drivers within qualitative storylines, we hypothesize that the relative absence
28532 of explicitly quantified technology and governance drivers is due to the complexities involved in
28533 parameterizing such uncertain drivers for inclusion in models. Economic drivers were frequently
28534 parametrized through increasingly questioned indicators, such as GDP.

28535 The direct drivers of pollution and invasive alien species also had limited coverage in exploratory
28536 scenarios compared to other direct drivers, such as climate change and land use change. Among
28537 pollution drivers, only nutrient emissions from agriculture were covered more frequently. Biological

28538 invasions were addressed only generally in most cases, assuming high or low levels of invasive alien
 28539 species, without specific assumptions regarding individual species.

28540 The review of integrated models revealed that integrated studies which attempt to capture some of
 28541 the complex interdependencies between human and environmental systems under multiple drivers of
 28542 change are rare, particularly for Eastern Europe and Central Asia. Furthermore, they are often limited
 28543 in the different social and ecological components that are coupled and the feedbacks between them
 28544 that are represented. Few studies specifically focus on nature and its contributions to people, although
 28545 such aspects can be included as part of a model chain or by linking the output of integrated models to
 28546 biodiversity or ecosystem service models. This is a key priority for future work to quantify impacts on
 28547 nature, its contributions to people, and good quality of life indicators under both exploratory and
 28548 normative scenarios (or pathways), including the uncertainties associated with such model
 28549 projections. Moreover, integrated models that accounted for nature's non-material contributions and
 28550 aspects of a good quality of life were rare, and the few that were found used simplified expert-based
 28551 approaches for representing the interrelationships. Few integrated modelling approaches have been
 28552 benchmarked or inter-compared to fully capture and quantify uncertainties from different approaches.
 28553 There is a significant gap in integrated assessments in terms of exploring the full range of synergies
 28554 and trade-offs between the multiple aspects of nature, its contributions to people, and a good quality
 28555 of life under different scenario archetypes and across different scales.

28556 Furthermore, nature is not a simple unit. Rather, any change in drivers will likely favour some
 28557 dimension of biodiversity (i.e. some species, variants, combinations of species that produce a given
 28558 ecological function) at the expense of others. As a result, nature is rarely included as a dependent
 28559 variable in scenarios. However, according to the IPBES conceptual framework, knowledge on the
 28560 responses of various facets of nature to various direct and indirect drivers, and on the effects of
 28561 changes in nature on changes in its contributions to people, would be crucial. Moreover, the
 28562 multifaceted character of biodiversity may also explain why integrated models struggle to capture
 28563 detailed impacts on biodiversity (many use simple indicators, such as mean species abundance or
 28564 biodiversity vulnerability indices). Coupling more sophisticated (process-based rather than statistical)
 28565 models of biodiversity and ecosystem functioning with models of human processes within integrated
 28566 assessment models would provide a more realistic assessment of the trade-offs between nature and
 28567 other indicators of socio-ecological systems. Despite these drawbacks, integrated modelling
 28568 approaches offer great promise in capturing some of the important interrelationships in complex
 28569 systems which are key to understanding the impacts of drivers on nature, its contributions to people,
 28570 and a good quality of life.

28571 The visions literature search yielded only a limited number of regional visions, with a small number of
 28572 visions from the scientific literature. For Western, Central and Eastern Europe, visions have already
 28573 been developed by different stakeholder groups and for several activity sectors. In Central Asia,
 28574 however, future planning is only covered by the strategic plans developed by governmental agencies.
 28575 Thematic gaps, for which societal visions have not been found, include marine ecosystems and urban
 28576 systems at the broad regional scale. The level of development of visions was very heterogeneous (from
 28577 a single paragraph to detailed descriptions of vision components), and most lacked quantitative goals
 28578 providing only qualitative orientating goals. Moreover, reviewed visions did not explicitly include a
 28579 diverse range of values in their narratives. Visions can also be "stakeholder-specific" with different
 28580 societal groups having different (and potentially conflicting) visions of the future. Visioning processes
 28581 which rationalize or accommodate these different viewpoints in their analysis are rare, although cross-
 28582 sectoral visions involving multiple stakeholders were found.

28583 Environmental goals within visions were mostly related to the need to reduce or avoid environmental
28584 impacts derived from human activity or in the context of nature's contributions to people. The
28585 underpinning role of nature and ecosystems in the delivery of these contributions and the
28586 maintenance of good quality of life was often missed. Finally, the analysis of visions content suggests
28587 that interregional flows are being overlooked, which could result in an aggravation of global
28588 inequalities.

28589 The pathways review found that there are very few fully developed pathways studies that go beyond
28590 narrative presentations of pathways and are supported by quantitative modelling. Nevertheless, well-
28591 developed narrative approaches may be just as valuable (if sometimes not more so) for empowering
28592 decision-makers and stakeholders, but this makes results more difficult to link with exploratory
28593 scenarios and formal analyses of specific drivers (i.e. analytical approaches) using quantitative
28594 modelling approaches. In addition, this lack of quantitative analysis means that pathway narratives
28595 express intent rather than feasibility, and that some trade-offs may be underestimated. Many
28596 pathways studies addressed trade-offs between nature's material contributions to people (food,
28597 timber, fisheries) and water provisioning and quality, global climate regulation and biodiversity
28598 conservation. However, consideration of biotic regulation services (e.g. pollination, pest control),
28599 natural hazard protection and non-material contributions were largely absent from trade-off analyses.
28600 Detailed descriptions and sequencing of actions within pathways was rare, as was information on
28601 combinations of policy instruments for implementing specific actions. With the notable exception of
28602 *transition movements* narratives, pathways to sustainability focused on very few dimensions of a good
28603 quality of life. The incorporation of combinations of exemplary *transition movements* pathways into
28604 large-scale scenario exercises and into participatory scenario development is suggested as a way
28605 forward for better resolving trade-offs and for scaling-up local or sectoral solutions. Furthermore,
28606 while investments were mentioned in a number of studies across the chapter, none of them provided
28607 systematic research to appropriately respond to the role of investments in the protection of
28608 ecosystems.

28609

5.7 References

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6 Chapter 6: Options for governance and decision-making across scales and sectors

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29400 **Executive summary**

29401 **Mainstreaming biodiversity and nature's contributions to people into policies, plans, programmes,**
 29402 **strategies and practices of public and private actors could be achieved if a more proactive, focused**
 29403 **and goal-oriented approach to environmental action were adopted (*well established*) (6.1, 6.3, 6.4,**
 29404 **6.5, 6.6). Key steps of mainstreaming include awareness raising, defining policy objectives as well as**
 29405 **designing appropriate policy instruments and policy mixes (6.6, Table 6.11).** Mainstreaming of
 29406 biodiversity is one of the major goals of international, regional and national biodiversity strategies
 29407 through clear and measurable objectives such as the Aichi Biodiversity Targets and relevant
 29408 Sustainable Development Goals (6.1, 6.3, 6.4.1). Progress has been made in Europe and Central Asia
 29409 towards mainstreaming biodiversity and nature's contributions to people by setting up, reviewing and
 29410 updating biodiversity strategies and action plans at multiple levels. Nevertheless, substantial efforts to
 29411 effectively implement existing legislation, and additional commitments to improve on the current
 29412 situation, are required to halt biodiversity loss and further ecosystem degradation (6.3, 6.4.1).
 29413 Mainstreaming biodiversity is essential for environmental policies (6.4.2), but even more so for
 29414 economic sectors and business actors depending on, or influencing, biodiversity (6.4.1, 6.5, 6.6, Table
 29415 6.11), such as agriculture (6.5.1), forestry (6.5.2), fisheries (6.5.3), energy and mining, manufacturing
 29416 (6.5.4) and services sectors (6.5.5). Opportunities to more successfully mainstream biodiversity and
 29417 nature's contributions to people, in public as well as private policy and decision-making, can be
 29418 harnessed through three key steps (6.6, 6.6.1, Figure 6.13, Table 6.11): (i) raising awareness on the
 29419 dependence of human well-being on nature, enhancing capacity-building and strengthening
 29420 participation of affected actors in decision processes; (ii) defining policy objectives concerning the
 29421 ecological, economic and socio-cultural needs for achieving sustainable living, taking account of the
 29422 diverse values of nature for different stakeholder groups; and finally, (iii) designing instruments and
 29423 policy mixes to support the implementation of effective, efficient and equitable policy- and decision-
 29424 making for nature and a good quality of life.

29425 **Developing integrated approaches that cut across sectors would enable more holistic and systematic**
 29426 **consideration of biodiversity and nature's contribution to people among public and private decision-**
 29427 **makers (*well established*) (6.1, 6.2, 6.4, 6.5, 6.6, 6.6.4.1, Figure 6.2). Further options are needed to**
 29428 **measure national welfare beyond current economic indicators, taking account of the diverse values**
 29429 **of nature (6.6.3.1). Environmental or ecological fiscal reforms provide an integrated set of incentives**
 29430 **to support the shift to sustainable development (6.4.1, 6.4.2).** There is a growing acknowledgement
 29431 that conventional sectoral approaches are proving insufficient to address interlinked environmental,
 29432 economic and societal challenges. Promising solutions may be devised more readily through integrated
 29433 approaches toward coordinating biodiversity governance and the sustainable delivery of nature's
 29434 contributions to people across sectors to avoid negative outcomes for people and nature (6.1, 6.4.1,
 29435 6.4.2, 6.6.4.1, Box 6.2, Box 6.9). Actions in one sector may impact other sectors and the contributions
 29436 of nature to people because trade-offs are rarely considered in the policy design, the choice of policy
 29437 instruments, or policy implementation (6.2, 6.4.1, 6.4.2, 6.6, 6.6.4.1, 6.6.4.2, Box 6.1, Box 6.9). Without
 29438 sustainable management practices, there is, for example, evidence that agriculture and forestry in
 29439 Europe and Central Asia may exert negative impacts on biodiversity and water quality and on the
 29440 livelihoods of indigenous peoples and local communities (6.5.1, 6.5.2, Table 6.6). In Western Europe,
 29441 multiple formal and informal institutions work against a societal transition to a low carbon economy
 29442 in the European Union (6.4.2). Similarly, in Central Asia, the combination of harmful subsidies and low
 29443 energy and water prices that do not take into account the "polluter-pays" principle, and environmental
 29444 standards based on outdated technology, may counteract general government priorities such as
 29445 resource efficiency and promotion of renewable energy (6.6.4). Policies only targeting supply security

and growth in the manufacturing, mining and energy sectors may come at the expense of biodiversity and nature's contributions to people, if they lack sufficient integration in wider policy agendas (6.5.4). Reflecting the real changes in the value of nature's contributions to people and of biodiversity in national income accounts is one policy option to provide better information to decision-makers and to help to counteract such trade-offs, also related to other economic sectors (6.6.3.1). Another option would be an environmental or ecological fiscal reform that creates an integrated set of incentives by redirecting taxation from labour to environment, including ecological indicators in intergovernmental fiscal relations and greening public expenditure programmes to support the shift to sustainable development (6.4.1, 6.4.2, 6.6.2). While recognizing and promoting synergies and solutions to the extent possible through policy integration, dealing with trade-off decisions will probably remain the rule rather than the exception (6.6.4). Conflicting policy goals between different sectors may lead to conflicting roles of instruments, and thus to trade-offs between biodiversity and the delivery of nature's contributions to people. Designing, implementing and assessing instruments in relation to their role in the overall policy mix helps to mitigate such trade-offs (6.2, 6.4.1, 6.5.5, 6.6.1, 6.6.2, 6.6.4.1, 6.6.5.5, Box 6.1). The use of proactive strategies, tools and methodologies to account for diverse values and criteria, and participatory processes, can support trade-off analyses and facilitate policy integration (6.4.1, 6.4.2, 6.6.4, 6.6.5).

Legal and regulatory instruments are the backbone of policy mixes and are necessary to promote the conservation, restoration and sustainable use of biodiversity as well as fair ecosystem governance for the long-term maintenance of ecosystems and for good quality of life (*well established*) (6.2, 6.3, 6.4, 6.5, 6.6, 6.6.5.1, Table 6.5, Table 6.11). Formal instruments such as laws, regulations, standards and planning instruments usually set the basic framework for other policy instruments to function (6.2, 6.3., 6.4.1, 6.4.2, 6.6.5, Table 6.2, Table 6.6, Table 6.9). They work through command and control, representing binding rules for governments, businesses, land users and citizens. These formal instruments are increasingly complemented by informal instruments. Ratifying and implementing international treaties and transboundary agreements provides a strong impetus for improving national and subnational policies in all sectors (6.3). For example, effective implementation of the Natura 2000 network in the European Union, as well as the Emerald Network as its extension to non-European Union countries and the Pan-European Ecological Network, help considerably to meet conservation objectives under international law. Marine protected areas, however, need more attention (6.4.1). For freshwater ecosystems, the European Union Water Framework Directive is of particular importance, as one way of achieving a good status for surface and groundwater. It requires member States to identify river basin districts and related authorities, which then develop management plans and programmes (6.3.2.3, 6.4.2, 6.5.1, 6.5.2, 6.5.3, 6.5.4, 6.6.3, 6.6.5.5). Such governance arrangements related to river basins at the local and regional level are thus embedded in national and European Union governance. Similar structures have also been developed in non-European Union countries, which are willing to align their management approaches to those of the European Union, such as Ukraine or Poland, which shares river basins with European Union countries (6.4.2). Furthermore, targeted spatial and urban planning across sectors and scales can substantially enhance the conservation and sustainable use of biodiversity and nature's contributions to people. Such planning helps to safeguard sensitive areas, improve the state of ecosystems, minimize current and potential future impacts, as well as identifying synergistic land-use options. Urban planning has particular responsibility in ensuring biodiversity conservation and the delivery of nature's contributions to people today and in the future, and in enhancing the quality of life of an increasing number of urban dwellers (6.6.4.2). Planning informed by biodiversity and nature's contributions to people can facilitate public participation and stewardship and provide the basis for targeted investments in nature's contributions to people, for example by designating specific areas for results-

oriented agri-environmental measures (6.6.4.2). Although regulatory instruments are the backbone of policy mixes, one key factor constraining the effectiveness of existing environmental governance arrangements is limited enforcement due, for example, to lack of institutional capacities and financial means, or corruption (6.3.1, 6.4.1, 6.4.2).

Economic and financial instruments complement existing regulatory and other policy instruments through approaches that balance conservation benefits and costs between actors and regions (*well established*) (6.2, 6.3, 6.4, 6.5, 6.6). Combatting continued biodiversity loss and ecosystem degradation requires, therefore, efforts to improve existing economic instruments as well as developing and implementing new economic instruments (*established but incomplete*) (6.2, 6.4.1, 6.4.2, 6.5, 6.6.2, 6.6.5.2, Table 6.5 ,Table 6.11). Economic and financial instruments include a wide range of designs and implementation approaches, both traditional and new (Table 6.2). They aim to change the behaviour of businesses, land users and citizens, but also public actors, through incentives and disincentives towards desired policy objectives. They incorporate the values of ecosystems into decision-making through corrected price signals, as present markets undervalue nature's contributions to people. Environmental taxes, charges and fees render environmental pollution and habitat degradation more expensive, thereby making the polluter pay, whereas payments for ecosystem services or compensation payments reward conservation-friendly behaviour that would otherwise not be profitable or affordable (6.4.1, 6.4.2, 6.6.5.2). Reforming environmentally harmful subsidies in sectors negatively affecting ecosystems is necessary to spend public funds cost-effectively in reaching conservation objectives. Innovative economic and financial instruments include biodiversity offsets and habitat banking, tax reliefs, ecological fiscal transfers, and integrated funding for biodiversity and climate change adaptation (6.4.1, 6.4.2, 6.5.1, 6.5.2, 6.5.3, 6.5.4, 6.5.5, 6.6.2, 6.6.3.2, 6.6.5.2). However, economic and financial instruments are context dependent and sometimes contested, as different actors hold different norms and values towards monetary incentives and towards using markets to achieve environmental and conservation goals (6.2, 6.4.1, 6.4.2, 6.6.2, 6.6.5.2). Economic and financial instruments need to be customized to national and local conditions to provide cost-effective means of achieving conservation targets, while considering social impacts (6.2, 6.4, 6.6.5). These instruments need, therefore, to be implemented with caution as they can have unintended social consequences and can also be detrimental to efforts to maintain and restore biodiversity and nature's contributions to people, for example when promoting intensification of agricultural and forest land use.

Social and information-based policy instruments have attracted significant interest in many policy sectors due to their capacity to integrate environmental concerns and trigger behavioural change at the local, national and international levels, and to include consumers and producers in policy development (*established but incomplete*) (6.2, 6.3, 6.4, 6.5, 6.6.5.3, Table 6.5 ,Table 6.11). If social and information-based instruments, such as voluntary market standards or social and environmental reporting, are to operate effectively as tools for conservation of biodiversity, sustained delivery of nature's contributions to people and poverty reduction, they have to be paired with the development of capacity-building and compliance mechanisms (6.4.2). Because of enhanced consumer awareness, media coverage, business commitment and sustainable government procurement, the market shares of, for example, certified products have risen considerably (6.6.5.3). Progress with certification is, however, very mixed in Europe and Central Asia, being better advanced in countries with developed market economies and less so in countries in economic transition (Table 6.11). In addition, there tends to be a trade-off between the efficiency of certification schemes and their accountability and impact, due to the lack of well-developed compliance mechanisms and clearly assigned responsibilities. Another set of social and information-based policy instruments, which has proven to be important in many countries in Europe and Central Asia, includes efforts to change social norms, through education

and information-based campaigns to promote pro-environment behaviour (6.2, 6.3.3, 6.4.1, 6.4.2.3, 6.5.1.2, 6.5.2, 6.5.3, 6.5.4, 6.5.5, 6.6.5.3).

Rights-based instruments and customary norms are increasingly supported and promoted by a wide range of multilateral environmental agreements, human rights and rights of indigenous peoples and local communities (*established but incomplete*) (6.2, 6.3, 6.3.2.5, 6.3.2.6, 6.4, 6.5, 6.6, 6.6.5.4, Table 6.11). These instruments, which integrate rights, norms, standards, and principles into policy, planning, implementation and evaluation, offer ways to reconcile biodiversity conservation and human rights standards (6.2, Table 6.2). While decisions by multilateral environmental agreements are implemented at the national level, the recognition of human rights, and in particular indigenous rights, in relation to conservation varies considerably between countries in Europe and Central Asia (Table 6.11). Further efforts would be needed, therefore, to develop better rights-based approaches to fully integrate the fundamental principles of good governance, equalizing power relations, and facilitating capacity building. Examples of such development can be seen in the governance trend emerging within the mining sector where traditional governance modes to mining are no longer sufficient for indigenous peoples and local communities. The demand for a greater share of income and participation has opened up for mining companies to gain a “social license to operate” from local communities, to avoid conflicts (6.5.4.3).

A wide range of actors is increasingly integrated into governance processes and this integration can have a positive impact on biodiversity and nature’s contributions to people if the effectiveness, efficiency and equity implications of the approach are carefully monitored, evaluated and improved (*well established*) (6.2, 6.4, 6.5, 6.6). In Western and Central Europe, and increasingly in Eastern Europe and Central Asia, the role of multi-actor environmental governance is recognized. In parallel to top-down governance, and decision-making concerning biodiversity and nature’s contributions to people is increasingly devolved to public-private partnerships, co-management arrangements or even private governance, involving a multitude of stakeholders. An example of such a policy is the European Union Water Framework Directive, which demands public participation in river basin management. A similar path of development can be seen in establishing new protected areas, or in the protection of cultural landscapes through the World Heritage Convention, the European Landscape Convention, and the IUCN protected landscape approach. These policies promote the protection, management, planning, and governance of cultural landscapes and voluntary forms of land management, such as through biosphere reserves or model forests. This development is driven by the importance of integrating various forms of knowledge, and the need to increase collective learning and adaptive management of natural resources. The evolution of governance, which includes changing responsibilities of public authorities, and how sectors are organized, varies substantially between sectors due to specific sector characteristics such as property rights, stakeholder commitments, transparency and degree of multi-functionality. To be able to assess the effectiveness, efficiency and equity of these promising governmental arrangements, and to take power relationships and asymmetries into consideration, careful evaluation and monitoring is required (6.2, 6.4.2.2, 6.5.1.2, 6.5.1.5, 6.5.1.6, 6.6.1, 6.6.2.2, Table 6.8, Box 6.7, Box 6.11).

Improving biodiversity conservation and nature’s contributions to people across administrative boundaries is limited without coordination, cohesiveness and sufficient mobilization of financial resources (*well established*) (6.3.2, 6.3.3, 6.4.1, 6.5.4, 6.6.2, 6.6.4). Increasing coordination between governance scales and levels and developing cohesive strategies and policy objectives among multilateral environmental agreement with the capacity to address problems related to biodiversity and nature’s contribution to people could improve the current multilevel governance system. This also holds for the uneven distribution of benefits and costs across space, actors, and time. Coordinated, multi-level approaches are especially important when ecosystems cut across administrative

jurisdictions between and within countries, and for addressing large-scale transboundary problems such as invasive alien species (6.3, 6.6). Furthermore, a key challenge for policy success consists in sufficient mobilization of financial resources (6.3.2, 6.3.3, 6.4.1, 6.5.4, 6.6.2, 6.6.4). Lack of adequate financing is a major constraint to achieve effective biodiversity conservation and ecosystem restoration (6.4.1). While a number of Western and some Central European countries of the European Union already provide substantial biodiversity-related financial development assistance to countries all over the world, there is still a need to mobilize more financial resources in Western Europe, but even more so in Central and Eastern Europe and Central Asia. Increased funding from public as well as private sources, together with innovative financing mechanisms, such as ecological fiscal transfers, would help to strengthen institutional capacities; to invest in research, training, capacity-building and education; to employ necessary staff; and to secure monitoring activities (6.3.2, 6.3.3, 6.4.1, 6.5.4, 6.6.2, 6.6.4).

There is no “one size fits all” for sustainable governance of biodiversity and nature’s contributions to people in a region as vast and ecologically, socially, politically and economically diverse as Europe and Central Asia (*well established*) (6.2, 6.3, 6.4, 6.5, 6.6). There are difficulties in transferring policies across regions, nations and sectors. Governance schemes and policies that are not designed and adapted to different economic, policy and societal sectors run the risk of not achieving their purpose. However, the role of learning, between different countries within Europe and Central Asia or from other world regions, should not be underestimated. On the contrary, it is important to create opportunities for accelerated development of learning and innovation processes if sustainable governance of biodiversity and nature’s contributions to people is to be achieved. Developing and improving governance systems to promote adaptive or transition management is therefore essential, if public and private actors are to achieve the overarching objective of safeguarding biodiversity, nature’s contributions to people, and good quality of life (6.6.6). Furthermore, learning and policy diffusion could be reinforced by improved coordination among international and transboundary institutions and across decision-making levels, taking due account of regional, national and subnational requirements; scientific as well as indigenous and local knowledge; and different socio-cultural contexts and related values (6.2, 6.3.1, 6.3.3, 6.4.2.2, 6.5, 6.6).

Addressing change is a matter of societal choice. How we choose to organize our societies – both the public and the private spheres – is key for the realization of pathways towards a sustainable future envisioned by a diverse range of actors in Europe and Central Asia (*well established*) (6.6.6). Our assessment shows that next to hierarchical decision-making, decentralization, public-private partnerships or private forms of governance, increasingly emerge. The design of promising governance options and smart institutional arrangements allow better involvement of different actors in policy and decision-making with the aim of promoting shared responsibility for our common future. In order to govern direct and indirect drivers in complex adaptive systems, which often includes various forms of incomplete knowledge, and involves risk, uncertainty, ambiguity or even ignorance, it is necessary to counteract institutional failures and to promote policy processes that stimulate adaptation and learning. Hence, policies, programmes and strategies constitute experiments that require (i) governance and management for change, rather than against change, and (ii) systematic, ongoing monitoring and evaluation. This can be achieved incrementally through adaptive governance and management and the systematic improvement of policy implementation, or via transition governance and management, and the organization of evolutionary processes of societal change (6.2, 6.4.2, 6.6, 6.6.6).

6.1 Introduction

This chapter explores governance options and institutional arrangements for better consideration of biodiversity and nature's contributions to people (NCP) in public and private decision-making in Europe and Central Asia. Biodiversity, nature's contributions to people, and good quality of life are relevant to a wide range of sectors and actors. Addressing the underlying causes of biodiversity loss and ecosystem degradation requires a critical assessment of primary economic sectors such as agriculture, forestry and fisheries as well as energy and mining (PBL, 2014; UNEP, 2011a). Their management practices, and the way in which these impact on nature, call for implementing existing policies more effectively and improving the current situation through additional commitments (UNEP & UNECE, 2016). There is considerable potential for more biodiversity-friendly, land-use practices, production methods and healthier consumer choices, for example through improved awareness raising, accounting tools, education and information-based instruments. This potential is also available to industries, manufacturing and the service sectors (TEEB, 2012). However, mainstreaming biodiversity across economic sectors and different stakeholder groups requires joint efforts by public and private actors and strong public policies to enable implementation of appropriate strategies (PBL, 2014; Secretariat of the CBD, 2011, 2014). Strengthening political support for environmental improvement is as necessary as building competent and effective environmental institutions, mobilizing finance for environmental and conservation priorities, monitoring progress and readjusting targets and integrating environmental policies into sectoral policies. This is highlighted by the regular Environmental Performance Reviews that cover the countries of Central Asia, Eastern Europe, Central Asia and the Balkan countries of Central Europe. Environmental governance and financing as well as integration of environmental considerations with economic sector policies are core elements of these reviews (UNECE, 2007, 2017c).

Previous ecosystem assessments at global, regional and national levels such as the Millennium Ecosystem Assessment (MA) or the UK National Ecosystem Assessment (UK NEA) have shown that policy integration across sectors and scales remains a crucial task (MA, 2005a, 2005b; UK NEA, 2011). Countries' 5th national reports to the Convention on Biological Diversity (CBD, 2016b) confirm that these challenges persist. As the interim assessment of national biodiversity strategies and action plans (NBSAPs) (Pisupati & Prip, 2015: 2) states, there is generally a poor correlation between these strategies and action plans and poverty alleviation, on the one hand, and strategies related to the Millennium Development Goals (MDGs), on the other, as well as between national biodiversity strategies and action plans and sectoral policies. The close link between human rights, ecosystem services and biodiversity is an important topic at the Human Rights Council, with the United Nations Special Rapporteur on human rights and the environment calling for more action from States to respect and protect the rights especially of those who are most vulnerable to the degradation and loss of biodiversity (Knox, 2017). However, with the recently adopted 2030 Agenda for Sustainable Development, the strengthening of human rights in relation to environmental issues has been improved as part of the 17 Sustainable Development Goals (SDGs) (United Nations, 2015). The Sustainable Development Goals are an integrated international policy agenda for the coming years; they are universal and apply to all countries in Europe and Central Asia. In this way, the 2030 Agenda for Sustainable Development is an overarching theme for the region (UNEP & UNECE, 2016).

"Mainstreaming" biodiversity involves *"the integration of the conservation and sustainable use of biodiversity in both cross-sectoral plans such as sustainable development, poverty reduction, climate change adaptation/mitigation, trade and international cooperation, and in sector-specific plans such as agriculture, fisheries, forestry, mining, energy, tourism, transport and others. It implies changes in development models, strategies and paradigms"* (Secretariat of the CBD, 2011, p. 5). Mainstreaming

biodiversity and nature's contributions to people across sectors in private and public decision-making, and simultaneously addressing challenges at various spatial and temporal scales, remains an important and continuous task. As the recently published GEO-6 assessment for the pan-European region (UNEP & UNECE, 2016, p. 8) has put it: *"Living within planetary boundaries will require fundamental transitions in energy, food, mobility and urban systems and entails profound changes in predominant institutions, practices, technologies, policies and lifestyles. New governance coalitions involving national and subnational levels of government, businesses and citizens are urgently needed."* A wide range of policy support tools and methodologies as well as different policy instruments are needed to realize these transitions (IPBES, 2016b). These tools and instruments address different actors in relevant sectors. Together they form policy mixes, with each of the instruments having a specific role in the overall policy mix for biodiversity conservation and the sustained provision of nature's contributions to people (Ring & Schröter-Schlaack, 2015).

Section 6.2 provides a framework for assessing governance options, institutional arrangements and policies in the context of the IPBES Regional Assessment for Europe and Central Asia, highlighting linkages between actors, sectors and instruments at different spatial scales. Section 6.3 provides an assessment of international, regional and transboundary environmental governance relevant to Europe and Central Asia. Sections 6.4 on biodiversity conservation and environmental policies and 6.5 on major economic sectors affecting biodiversity and nature's contributions to people, adopt a sectoral perspective: What are the major policy objectives, predominant governance modes and instruments currently governing these sectors? What are key constraints or opportunities within these sectors regarding biodiversity and nature's contributions to people? Which existing and novel options have been proposed in the scientific literature for better governance of biodiversity and nature's contributions to people in these sectors and to what extent have these options and opportunities been implemented or initiated by different actors? Finally, Section 6.6 synthesizes major insights for mainstreaming and integrating biodiversity and nature's contributions to people within and across different sectors; highlights areas for successful integration such as environmental accounting, spatial planning or progress in sustainable consumption and production; and assesses major categories of policy instruments.

6.2 Framing institutions and policy options for biodiversity and ecosystem governance

Smart governance options and institutional arrangements are essential for the conservation and sustainable use of biodiversity, long-term human well-being and sustainable development (Meadowcroft, Langhelle, & Ruud, 2012). Institutions and governance and other indirect drivers affecting biodiversity and nature's contributions to people have deliberately been placed at the centre of the IPBES conceptual framework (Díaz et al., 2015), and this has been highlighted as an improvement on the Millennium Ecosystem Assessment (Borie & Hulme, 2015; MA, 2005a). The way in which people and societies organize themselves and their interactions with nature at different scales, indirectly drives biodiversity and ecosystem change (Díaz et al., 2015). Governance and institutions thus influence all aspects of relationships between people and nature. Formal and informal institutions determine values and the ways in which responsibilities, costs and benefits of biodiversity conservation are distributed across society. Formal institutions include written constitutions, laws, policies, rights and regulations enforced by official authorities. Informal institutions are mostly unwritten social norms and rules, customs and traditions such as those related to collective action (North, 1990; Ostrom, 1990).

Biodiversity and ecosystem governance benefits from involving the full range of public and private actors, and drawing on a variety of coordination and interaction mechanisms. In contrast to public policies pursued by *governments* at various administrative levels, biodiversity and ecosystem *governance* promotes societal transformation by a number of different actors, including governments, business and civil society (Paavola, Gouldson, & Kluvánková-Oravská, 2009; Ring, 2008a). Governance processes occur at various spatial (local to international) and temporal scales, and affect different societal, economic and policy sectors (Lange, Driessen, Sauer, Bornemann, & Burger, 2013). Different modes of governance are typically viewed along a continuum between state intervention and societal autonomy (Table 6.1).

Table 6.1: Governance modes, public and private actors and their interaction. Source: adapted from Driessen et al. (2012) and Lange et al. (2013).

	Hierarchical governance (centralized)	Decentralized governance	Public-private governance	Self-governance/ Private governance
Actors	Mainly central governmental (or supranational) bodies	Governmental actors at lower levels (subsidiarity)	Central government agencies; private sector – market actors (business, consumers)	Mainly non-governmental: Private sector or civil society (NGOs, indigenous peoples and local communities, citizens)
Power	Coercion	Coercion	Competitiveness (prices); contracts; agreements	Autonomy
Representation	Pluralist ((supra)national elections)	Pluralist (local elections)	Corporatist (formalized public-private arrangements) as well as public-private partnerships	Partnerships (participatory private-private governing arrangements)
Mechanisms of social interaction	Top-down; command and control	Sub-national governments decide autonomously within top-down determined boundaries	Private actors decide autonomously about collaborations within top-down determined boundaries or based on negotiations	Mainly bottom up; social learning, deliberation, negotiation

At one end of the continuum, hierarchical decision-making by governments has traditionally shaped environmental and biodiversity conservation policies through standards and other regulatory measures. Decentralized governance is still top-down in its approach, yet subsidiarity allows lower governmental levels to take decisions autonomously. These publicly determined governance modes have increasingly been complemented by other approaches. These range from institutionalized public-private relations, that leave market actors more freedom to choose their actions within predetermined boundaries (e.g., incentive-based instruments such as environmental taxes or payments for environmental services), to public-private partnerships with negotiated agreements, to modes of self-governance at the other end of the continuum (e.g., by private-social partnerships). With the centre of power no longer only involving the state, but different spheres in society (State, market actors, and civil society), polycentric governance has become increasingly important (Driessen et al., 2012; Muradian & Rival, 2012; Primmer et al., 2015), transcending the above-mentioned continuum in combining different modes of governance with various actors, from public to private.

The European Union (EU), for instance, combines hierarchical governance with decentralized governance and public-private partnerships. It provides a legal and institutional framework in almost all policy sectors for European Union member States in Western and Central Europe. Yet, the European Union's "subsidiarity principle" as set out in Article 5(3) of the Treaty on European Union states that the European Union "*shall act only if and in so far as the objectives of the proposed action cannot be sufficiently achieved by the Member States, either at central level or at regional and local level, but can rather, by reason of the scale or effects of the proposed action, be better achieved at Union level*" (European Union, 2016b). In addition, the European Union has developed new experimental modes of governance, such as the open method of coordination that is based on soft law mechanisms such as guidelines and indicators (EUR-lex, 2017). The open method of coordination has increased the competence of the European Union to regulate areas where the traditional Community legislative processes are weak, or where new areas require coordination of member state policy.

For Eastern Europe and Central Asia, most of the literature still focuses on centralized approaches to governance, but the role of multi-actor governance is also increasingly recognized (OECD, 2005, 2012a). Civil society actors such as NGOs play an important role and can be influential in the design of relevant legislation and programmes over time (Yamin, 2001). The European Platform for Biodiversity Research Strategy is an example of cooperation between researchers, policy makers and other stakeholders, a science-policy interface and forum aiming to promote knowledge for sustainability, with a focus on the conservation and sustainable use of biodiversity and ecosystem services science and policy (EPBRS, 2016). The BioNET network is a regional network of biodiversity-related civil society organizations in the Balkan countries in Central Europe. The network promotes democratic development and strengthening cooperation and dialogue between local authorities, national governments, civil society, private sector and international governmental and non-governmental organizations conducive to nature conservation as one key element of sustainable development (GIZ, 2016). Civil society networks such as the River without Boundaries Coalition, founded by several NGOs from Russia, China, Mongolia and USA, is uniting citizens from transboundary regions in one movement to campaign for the protection of the Amur River basin, which is the largest free-flowing transboundary river system in Asia (Rivers without Boundaries Coalition, 2017).

Despite improvements in governance in Europe and Central Asia, biodiversity loss and ecosystem degradation are still exacerbated by various institutional failures. These are often catalogued as: (i) law and policy failures (e.g., environmentally harmful subsidies); (ii) market failures (externalities in the use of public goods and services); (iii) organizational failure (e.g., lack of transparency and political legitimacy in decision-making, and implementation deficits); and (iv) informal institutional failures (e.g., breakdown in collective action norms such as free-riding or crowding out intrinsic motivations for biodiversity conservation due to erosion of trust) (IPBES, 2016a, 2016b; Ostrom, 1990; Rode, Gómez-Baggethun, & Krause, 2015). To counteract these failures, strategies are formulated and concrete policy goals are set, which aim at designing and implementing policy instruments that avoid negative impacts on biodiversity and ecosystems services or support and promote environmentally-friendly behaviour (**Figure 6.1**) (IPBES, 2016b). Finally, a pool of policy support tools and methodologies is available to inform instrument design or stakeholders' activities for better biodiversity and ecosystem governance.

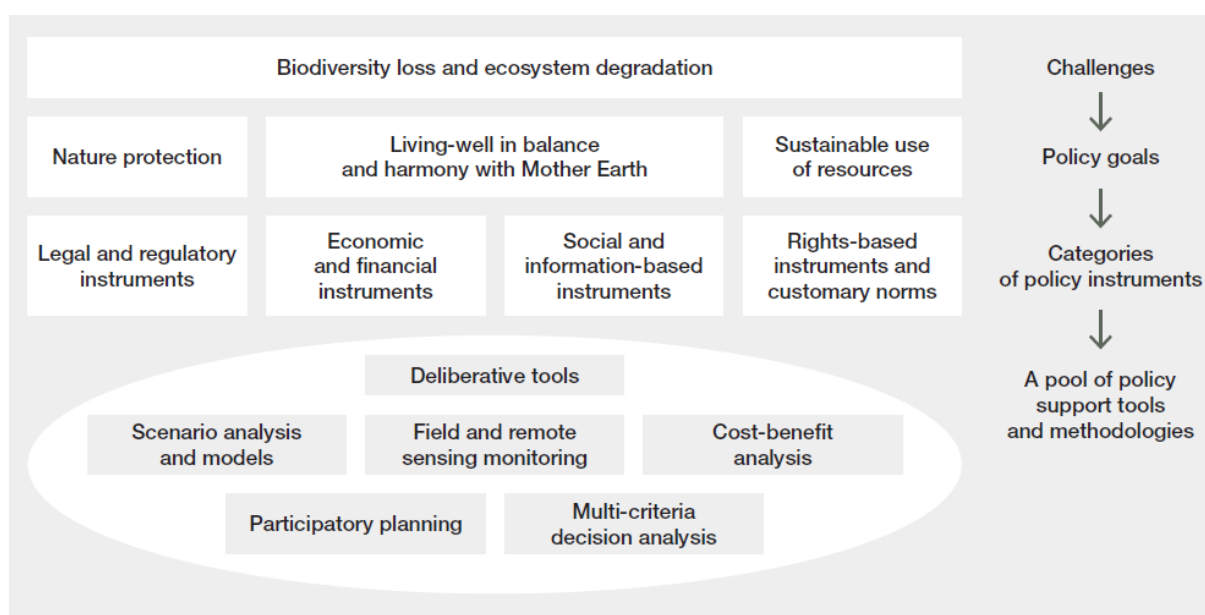


Figure 6.1: Schematic representation of the interrelation of policy formulation, policy instruments and policy support tools and methodologies. Source: adapted from IPBES (2016b).

Biodiversity and ecosystem governance can build on a wide range of policy instruments as well as supporting tools and methodologies. In the context of IPBES, policy instruments have been placed into four main categories (for more detail on these categories see (IPBES, 2016a, for more detail on these categories see 2016b):

- legal and regulatory instruments;
- economic and financial instruments;
- social and information-based instruments; and
- rights-based instruments and customary norms.

Legal and regulatory instruments, or so-called “command and control” measures have long been applied to deal with environmental degradation (Harring, 2014). (Schröter-Schlaack & Blumentrath, 2011) refer to “direct regulation” as environmental and technical standards as well as spatial planning. They provide three reasons why direct regulation is often the first choice for policy makers when faced with an environmental problem: (i) it is supposed to permit a fast and direct response; (ii) policy makers are experienced in using this type of instrument; and (iii) established legal institutions are often an important prerequisite for implementing economic and financial instruments.

Economic and financial instruments comprise (i) price-based mechanisms (e.g., subsidies, taxes, fees, payments, fiscal transfers), and (ii) quantity-based mechanisms (e.g., tradable permits, land-development rights, habitat banking) (Schröter-Schlaack & Ring, 2011). They are intended to change private and public actors’ behaviour through incentives or disincentives towards desired policy objectives. Typically, they comprise a wide range of designs and implementation approaches, and are able to support manifold strategies concerning biodiversity and ecosystem services. They can be used to correct for policy and market failures, and aim at reflecting monetary costs or benefits of the conservation and use of biodiversity and ecosystem services (IPBES, 2016b). Thus, environmental fiscal reforms are important to change relative prices in the whole economy. Furthermore, Aichi Biodiversity Target 3 highlights the importance of reducing negative impacts of harmful subsidies and increasing positive incentives for conservation. However, until now substantial reforms have not taken place. Several countries in Eastern Europe and Central Asia have taken steps towards environmental fiscal reforms with mixed results (CBD, 2017a). The suitability of specific fiscal instruments for individual

29820 countries depends among others on the country's stage of development, level of resource endowment
29821 and institutional capacity (The World Bank, 2005).

29822 Social and information-based instruments consider the interdependence of ecosystems and
29823 sociocultural dynamics for successful environmental management at the local, national or regional
29824 level. They comprise: (i) information related instruments such as environmental education, eco-
29825 labelling, certification, and awareness raising; (ii) self-regulation, voluntary agreements and corporate
29826 social responsibility; (iii) participation; and (iv) enhancement of collective action of indigenous peoples,
29827 local communities, and local resource users (IPBES, 2016b).

29828 The rights-based approach is often defined as a way of *"integrating rights, norms, standards, and*
29829 *principles into policy, planning, implementation, and outcomes assessment to help ensure that*
29830 *conservation practice respects rights in all cases, and supports their further realization where possible"*
29831 (Campese, Sunderland, Greiber, & Oviedo, 2009, p. 8). Thus, the rights-based approach offers a range
29832 of instruments to reconcile conflicts primarily through the improvement of governance procedures of
29833 biodiversity and ecosystem services. This includes elements that to a large extent overlap with the
29834 principles of good governance, such as participation, transparency; accountability (Biermann & Gupta,
29835 2011; Ratner, Meinen-Dick, May, & Haglund, 2013), and empowerment (Ensor, Park, Hoddy, &
29836 Ratner, 2015). Rights-based instruments and cultural norms are increasingly gaining interest in the
29837 field of natural resource conservation and management (Campese et al., 2009; Jodoin, 2014). The
29838 instruments included in the rights-based approach may offer ways to reconcile conservation and
29839 human rights standards, and foster complementarity with human wellbeing (IPBES, 2016b). However,
29840 the practical implications of conserving biodiversity and, at the same time, protecting human rights
29841 are still rather unclear and therefore subject to much debate in particular when it comes to the rights
29842 of indigenous peoples (Reimerson, 2013).

29843 Examples of instruments belonging to the various instrument categories are provided in **Table 6.2**. It
29844 is difficult to connect value types (anthropocentric and non-anthropocentric) to specific policy
29845 instruments or governance modes. Legal and regulatory instruments can capture a wide range of
29846 values, including economic ones, for example through fines, and not all economic and financial
29847 instruments relate exclusively to monetary values derived by economic valuation methodologies.

29848 Although the design and evaluation of policy instruments has mostly focused on individual
29849 instruments, in practice, policy instruments are used in combination, as a policy mix, which *"has*
29850 *evolved to influence the quantity and quality of biodiversity conservation and ecosystem service*
29851 *provision in public and private sectors"* (Ring & Schröter-Schlaack, 2015). Specific policy outcomes may,
29852 therefore, be due to individual policy instruments, but there may be cases where other instruments
29853 create synergies towards achieving objectives or cause conflicts that impede achievement of the
29854 envisaged outcomes. Possible interactions of instruments comprise co-existence (incl.
29855 complementarity, redundancy and overlap), synergies, competition and conflict, and sequential
29856 interaction (e.g. implement enabling legal and regulatory instruments before economic instruments
29857 that may require well-defined property rights) and replacement (Jordan, Wurzel, & Zito, 2013; R.
29858 Santos, Schröter-Schlaack, Antunes, Ring, & Clemente, 2015). Therefore, policy mix analysis and
29859 highlighting the role of instruments in a policy mix have increasingly gained attention in research and
29860 policy practice (Gunningham & Young, 1997; P. Lehmann, 2012; OECD, 2007; Ring & Barton, 2015; Ring
29861 & Schröter-Schlaack, 2011). Further concepts highlighting the coordination and integration of
29862 instruments include on the one hand the spatial fit to avoid mismatches between ecological and social
29863 processes or boundaries, and on the other hand the interplay and interconnections between regimes
29864 (Kim, 2004; Moss, 2012; Vatn & Vedeld, 2012).

29865

29866 **Table 6.2: Policy instrument categories. Source: Own representation.**

Legal and regulatory instruments	Economic and financial instruments	Social and information-based instruments	Rights-based instruments and customary norms
<ul style="list-style-type: none"> – Legislation – Standards – Environmental quality objectives – Planning – Threshold values – Liability rules – Impact regulations – Long-term agreements – Environmental classification – Technology requirements – Supervision 	<ul style="list-style-type: none"> – Taxes – Tax reliefs – Charges – Fees – Allowances – Offsets – Emissions trading – Habitat trading – Ecological fiscal transfers – Subsidies – Compensation payments – Payments for environmental services 	<ul style="list-style-type: none"> – Information – Pollutant release and transfer registers – Biodiversity registers – Ecolabeling – Certification – Counselling – Education/Training – Opinion forming – Corporate Social Responsibility – Self-regulation – Voluntary agreements – Cooperation and consultation – Networks 	<ul style="list-style-type: none"> – International and national human rights instruments – Strengthening of collective rights – Customary norms and institutions of indigenous peoples and local communities – Equitable and fair management of natural resources – Heritage sites: e.g., sacred sites, peace parks, indigenous and community-conserved areas

29867

29868 The different conceptualizations of the diverse values of biodiversity and nature's contributions to

29869 people are important for choosing the most appropriate instruments and further options in any

29870 context (see Chapters 2 and 3; and (Chan, Satterfield, & Goldstein, 2012; IPBES, 2016a; Kenter et al.,

29871 2015, 2016). The choice of policy instruments often implies altering the distribution of responsibilities

29872 for the conservation and use of biodiversity that goes along with changing the advantages and

29873 disadvantages for different actor groups. Different actors also hold competing norms and values that

29874 influence the type of policies they support, and this relates to the choice and design of policy

29875 instruments to achieve certain objectives. Whereas some stakeholders prefer regulatory instruments,

29876 others favour economic and financial instruments. However, any policy instrument can only be

29877 effective if the supporting formal and informal institutions are in place. Legal and regulatory

29878 instruments such as laws, regulation and plans usually set the boundaries within which economic

29879 instruments are then applied to incentivize public and private actors towards more environmentally-

29880 friendly behaviour (Vatn, 2015). Local communities and indigenous peoples often build on traditional

29881 knowledge for land-use practices. They may have developed customary norms in relation to special

29882 places in nature, respected as sacred sites or community-conserved areas, but these may not be

29883 recognized in formal conservation policies or regulatory developments at distant national, regional

29884 and international levels (Babai et al., 2015; Borrini-Feyerabend, Kothari, & Oviedo, 2004; Samakov &

29885 Berkes, 2016). Granted concessions to business companies for the exploration and extraction of

29886 natural resources and minerals may thus, for instance, not recognize or may even violate indigenous

29887 and local people's access to and traditional use of local resources and ecosystem services

29888 (Bogoslovskaya, 2015; Fondahl & Sirina, 2006; Stammeler & Forbes, 2006), as well as disregarding their

29889 spiritual relationship with nature (Lavrillier, 2013).

29890 Considering the mix of instruments is especially important in an ecosystem-service perspective where

29891 trade-offs and synergies may occur between biodiversity and ecosystem services or among different

ecosystem services (Elmqvist et al., 2010; Ring & Schröter-Schlaack, 2015). Policy-mix analysis is also essential where policies in one sector, e.g., climate, fisheries, energy or agriculture, may jeopardize policies in another such as nature conservation. Terrestrial, freshwater, coastal and marine systems in Europe and Central Asia are exposed to manifold threats. Indirect drivers as assessed in Chapter 4 include institutional, economic, demographic, cultural and religious as well as scientific and technological drivers. The most important direct drivers of change are natural resource extraction, land-use change, pollution, climate change and invasive alien species (see Chapter 4). Relevant sectors, their governance modes, policies and instruments and the coherence between them have to be assessed at different spatial levels if the aim is to identify promising policy options and opportunities for public and private actors, to promote positive and mitigate negative impacts on biodiversity and nature’s contributions to people, and hence on good quality of life (Figure 6.2).

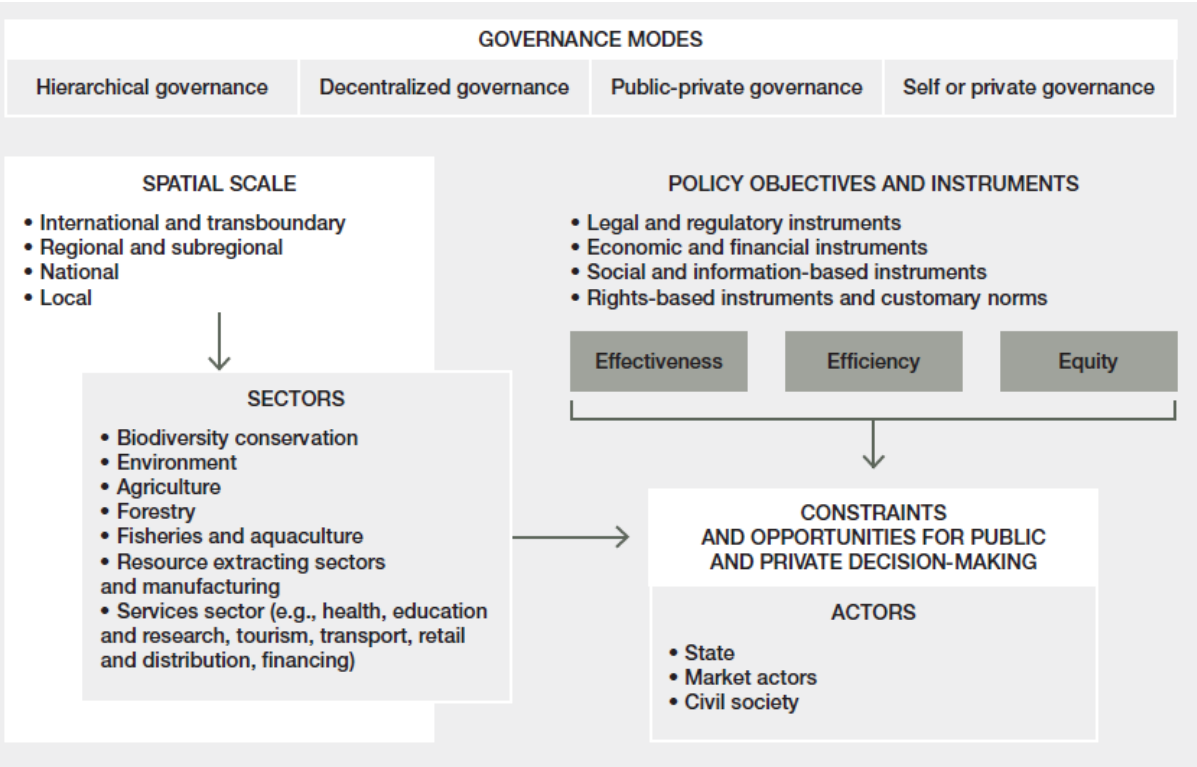


Figure 6.2: Assessing governance options and policy instruments in key sectors. Source: Own representation.

Policy instruments are often analyzed regarding their effectiveness and efficiency (including cost-effectiveness) in reaching an environmental objective. Effectiveness comprises the assessment of the outcomes achieved with respect to different policy approaches, while efficiency deals with the (economic) comparison of inputs and outputs. Further policy assessment criteria include equity, social and distributive impacts, policy coherence, administrative feasibility, relevance and institutional requirements, among others (OECD, 1997; Ring & Schröter-Schlaack, 2011; Sterner, 2003; R. K. Turner & Opschoor, 1994). Equity touches upon raising social awareness and enhancing participation as well as legitimacy and transparency in the decision-making process, thereby improving the distribution of benefits and reducing social conflicts (Bagnoli, Goeschl, & Kovács, 2008; Felipe-Lucia et al., 2015; Grieg-Gran, Svarstad, Porras, & Mohammed, 2013; Martin-Lopez et al., 2012; McDermott, Mahanty, & Schreckenber, 2013; Wilson & Howarth, 2002) (see also Chapter 2, Section 2.3.4). However, it should be acknowledged that it is extremely difficult to assess and to draw general conclusions on the

effectiveness, efficiency or equity of any given instrument category or a mix of instruments as, ultimately, their success largely depends on instrument design and the coordination and integration between different policy fields.

29922

29923 **6.3 International, regional and transboundary environmental governance**

29924 **6.3.1 Intergovernmental and non-governmental organizations**

29925 In Europe and Central Asia environmental governance at the international level is based on a network
29926 of intergovernmental organizations and international non-governmental organizations, and plays an
29927 increasingly significant role in environmental governance (Esty & Ivanova, 2002) and advocates for
29928 specific policies at the international as well as national and subnational level (Eilstrup-Sangiovanni &
29929 Bondaroff, 2014; Esty & Ivanova, 2002). Membership of intergovernmental organizations may
29930 comprise sovereign states or of other intergovernmental organizations with the main aim of creating
29931 a mechanism for countries to work more successfully together in, for example, the areas of
29932 biodiversity, nature's contributions to people, and good quality of life. International non-governmental
29933 organizations are generally private, voluntary organizations, whose members are individuals or
29934 associations that come together to achieve a common purpose.

29935

29936 **6.3.1.1 Intergovernmental organizations**

29937 Intergovernmental organizations are bodies based on a formal instrument of agreement such as a
29938 treaty or charter and possessing a permanent secretariat performing ongoing tasks (Oberthür &
29939 Gehring, 2006; Speth & Haas, 2006). At the global level, intergovernmental organizations relevant to
29940 biodiversity and nature's contributions to people include the United Nations Environment Programme
29941 (UNEP), the United Nations Development Programme (UNDP), and other specialized United Nations
29942 agencies and commissions such as the Food and Agriculture Organization of the United Nations (FAO).
29943 A variety of other international organizations plays an important role in coordinating environmental
29944 policy. The World Bank influences policy directly through its environmental strategy, and indirectly
29945 through development activities for the environment. The Global Environment Facility (GEF) sets
29946 priorities and processes for funding many environmental projects and the World Trade Organization
29947 (WTO) influences environmental policies through trade agreements. The Organisation for Economic
29948 Co-operation and Development (OECD) addresses the economic, social and governance challenges of
29949 globalization and aims to exploit its opportunities (Oberthür & Gehring, 2006).

29950 Within Europe and Central Asia specific intergovernmental organizations, such as the Council of Europe
29951 and the European Union (EU) have prominent roles in environmental policy making. The European
29952 Union is commonly described as an international organization *sui generis* due to its uniqueness with
29953 regard to supranational features and strong elements of legal integration (Tömmel, 2011). The
29954 European Union is founded on the rule of law and on the principle of conferral (European Union,
29955 2016b, Articles 2 and 5.2). This means that it only has the competences that have been voluntarily and
29956 democratically transferred to it from the member States in the founding Treaties. As described in
29957 Section 6.3.2.3 below, the European Union has developed a significant amount of environmental
29958 legislation and policy decisions over the years, and is party to several multilateral environmental
29959 agreements.

29960 In addition to these intergovernmental organizations there are also a number of organizations or
29961 treaties related to specific geographical areas within Europe and Central Asia, for example the Arctic,

the Barents, the Mediterranean and the Alpine areas. In the absence of a treaty, an intergovernmental organization does not exist in a legal sense. For example, the G8 is not an intergovernmental organization, but a group of eight nations that have annual economic and political summits. Intergovernmental organizations that are formed by treaties and thereby subject to international law are more advantageous to more informal groups since they have the ability to enter into enforceable agreements among themselves or with states (Speth & Haas, 2006). However, this does not mean that one should underestimate the impact of informal groups such as the G8 on the governance of biodiversity and nature's contributions to people, since such groups may, based purely on the collective influence of their members, be able to play a prominent role in global environmental governance (Speth & Haas, 2006).

Although intergovernmental organizations have come to play a significant role due to increasing globalization and interdependence of nations, their activities and objectives often overlap, resulting in a complex network; or they may have difficulty integrating competing objectives, as in the following case of global trade and the environment. The World Trade Organization still lacks a special agreement on the environment, but most agreements formalized within its domain include environmental regulations that require member States to ensure that the environment is duly protected. However, it has been challenging to recognize the ecological impacts of trade, such as biodiversity losses and destruction of ecosystems; and to develop an environmental policy framework that complements trade policies (Santarius, Dalkmann, Steigenberger, & Vogelpohl, 2004). Another challenge lies in the policy conflicts between multilateral environmental agreements and the World Trade Organization trade policy. These conflicts arise because environmental agreements often aim to internalize negative external costs, i.e. to reduce environmentally harmful economic activities, while this is often ignored in free trade policies. Hence, international trade policies have significant impact on the environment and potential to trump international environmental policies when they come into conflict (Santarius et al., 2004).

In sum, intergovernmental organizations contribute to and develop habits of environmental cooperation, and regular interactions among nation States. While some intergovernmental organizations establish regularized processes of information gathering, analysis, and monitoring, others develop procedures to make rules, to settle disputes, and to punish those who do not comply to the rules. However, the multitude of intergovernmental organizations also gives rise to fragmented, sometimes overlapping and occasionally conflicting legal and policy mandates, which may complicate the ability of countries in Europe and Central Asia, and beyond, to achieve established goals.

6.3.1.2 International non-governmental organizations and hybrid organizations

International non-governmental organizations are generally voluntary organizations, often politically independent, that may participate at all political levels from the global to the local. From an environmental governance perspective, they are increasingly significant, especially in Europe and Central Asia. They may be funded solely through private sources or rely on partial government funds. Currently there are 4,189 international non-governmental organizations and non-governmental organizations that enjoy active consultative status with the United Nations Economic and Social Council (NGO Branch, 2017).

As advocates for specific policies, they may offer alternative channels of political participation, and play a role in collecting, disseminating, and analyzing information; provide input into agenda-setting and policy development processes; perform operational functions; assess environmental conditions and monitor compliance with environmental agreements; and advocate environmental justice

30007 (Bernauer, Böhmelt, & Koubi, 2013; Eilstrup-Sangiovanni & Bondaroff, 2014; Esty & Ivanova, 2002).
 30008 International non-governmental organizations may also be major operators of conservation initiatives
 30009 in practice at various levels (Redford et al., 2003). In contrast to intergovernmental organizations,
 30010 international non-governmental organizations rely on soft power, i.e. information, expertise, and
 30011 moral authority to attract the support of Governments and the public (E. A. L. Turner, 2010). However,
 30012 at the national level, non-governmental organizations have also occasionally taken the place of a state
 30013 when the state has not been able to perform as intended in protecting the environment (Borrini-
 30014 Feyerabend et al., 2013), for example in the case of political or military conflicts or corruption.

30015 In general, very little is known about the degree of attention that government representatives pay to
 30016 the input of non-governmental organizations in international negotiations, or which strategies are
 30017 effective when employed to make an impact, such as activism, lobbying or expert-influence.
 30018 International non-governmental organizations also have to evaluate their respective strategies to
 30019 make an impact in relation to the risk of being co-opted by Governments. Many non-governmental
 30020 organizations address this challenge by specializing in either activist strategies (e.g., Greenpeace) or
 30021 hybrid strategies with closer ties to governments, including partnerships (e.g., World Wide Fund for
 30022 Nature). This attracts different groups of supporters and will also influence the funding structures
 30023 ranging from public grants (e.g. European Commission and national grants), to membership
 30024 contributions, donations, or crowd funding (Rietig, 2016).

30025 A sharp distinction is often made between intergovernmental organizations and international non-
 30026 governmental organizations. In practice, however, governments do not always strictly maintain the
 30027 separation. There is an increasing number of hybrid organizations involving both intergovernmental
 30028 organizations and international non-governmental organizations. One of the most prominent in
 30029 environmental governance is the International Union for Conservation of Nature. The International
 30030 Union for Conservation of Nature has observer status at the United Nations and consultative status
 30031 with the United Nations Economic and Social Council, Food and Agricultural Organization, and United
 30032 Nations Educational, Scientific and Cultural Organization. The International Union for Conservation of
 30033 Nature has played an important role in the management and conservation of biodiversity, globally as
 30034 well as in Europe and Central Asia. Two of their instruments have played particularly important roles:
 30035 the Red List of Threatened Species, and the framework for governance models of protected areas. The
 30036 latter has opened up for a larger variation of governance and management of protected areas also
 30037 including indigenous peoples and local communities, as well as privately managed areas. Despite this
 30038 development, most protected areas in Europe and Central Asia still have hierarchical modes of
 30039 governance (Borrini-Feyerabend et al., 2013; Holmgren, Sandström, & Zachrisson, 2016; Reimerson,
 30040 2013).

30041 Another example where intergovernmental organizations and international non-governmental
 30042 organizations come together is the “Environment for Europe” process. This process is a public-private
 30043 partnership including 54 countries in Europe and Central Asia partnering with international
 30044 organizations as well as regional environmental centres, non-governmental organizations and the
 30045 private sector. The objective is to harmonize environmental policies and enhance the quality of the
 30046 environment across Europe, but also to help countries of Eastern Europe, Central Europe and Central
 30047 Asia to improve their environmental standards (UNECE, 2017a).

30048 In sum, international non-governmental organizations play an important role in pushing for sustainable
 30049 development at the international level, in particular in transition countries (Bernauer et al., 2013). They
 30050 are key drivers in intergovernmental negotiations on environmental governance. International non-
 30051 governmental organizations also increasingly pay attention to social and environmental externalities
 30052 of business activity. Multinational brands may be pressured by international non-governmental

organizations challenging their labour, environmental or human rights record, for example through “naming and shaming” activities (Keskitalo, Sandström, Tysiachniouk, & Johansson, 2009). International non-governmental organizations thus play an important role in relation to both public and private activities related to biodiversity and nature’s contributions to people, given that they are afforded freedom to play a vital role and that they can find funding for their activities.

Some critics are, however, concerned that they may contribute to the fragmentation and weakening of political action. There are, for example, often competing international non-governmental organizations in the same policy field and their mutual contest for influence risks undercutting political effectiveness. Supporting and incentivizing coordination and collaboration among international non-governmental organizations is thus an important opportunity among actors at multiple levels in Europe and Central Asia in relation to the increasing influence of civil society in environmental governance at the global level (Esty & Ivanova, 2002).

6.3.2 Responses to global environmental challenges

Since many natural resources are shared and many environmental problems have a global or transboundary nature, they can only be addressed effectively through different forms of international or regional cooperation among States (Sands, Peel, Fabra, & MacKenzie, 2012). To understand and assess how the international level impacts on countries within Europe and Central Asia with respect to biodiversity and nature’s contributions to people, one needs to comprehend the strengths and weaknesses of the international system, especially of the international environmental law. In the international arena, States are the primary legal subjects and the bearers of rights and obligations (Cassese, 2005). International law, or law of nations, consists of rules for the legal relations between and among States, international organizations and non-state actors. All international cooperation is voluntary, since all States are sovereign and equal (Sands et al., 2012). However, ensuring compliance with international law is often problematic, since international agreements seldom include direct reprisals or sanctions (Beyerlin & Marauhn, 2011). Implementation and enforcement of international law in general, and environmental law in particular, rest on States’ political standing and good will to comply (Sands et al., 2012), and their ability to establish effective international cooperation. International environmental law provides a meta-framework for international relations, thereby providing rules and regulations that for example determine the legality of State actions with respect to ecosystem services that cross national boundaries. International law is thus important in providing a platform for identifying, integrating and implementing legal, scientific, and policy issues at national level relevant to the conservation and use of biodiversity, and nature’s contributions to people, that cross political or administrative boundaries.

In contrast to the four categories of policy instruments adapted from IPBES (IPBES, 2016a, 2016b) and introduced in Section 6.2, international law is broadly divided into two main categories: 1) legally binding international law (hard law); and 2) non-legally binding international law (soft law). The Statute of the International Court of Justice, in its Article 38, declares that there are three main sources of binding international law: a) international treaties, conventions and protocols (binding only on the parties to the agreement); b) international custom, built on established practice and considered to be binding on all States; and c) general principles of law recognized by civilized nations (Thirlway, 2003).

Today there has been an increasing use of non-binding normative instruments in the international arena (Shelton, 2014). Such soft law instruments, international resolutions and declarations, or informal supervisory organs to international agreements, are commonly described as including hortatory, i.e. incentivizing or encouraging means, rather than legal obligations (Guzman & Meyer,

2010). New governance mechanisms and increasing interactions between governance levels are established today at the international level (Derx & Glasbergen, 2014; Glasbergen, Biermann, & Mol, 2007; Visseren-Hamakers, Leroy, & Glasbergen, 2012).

Over time, a vast number of international and regional environmental governance arrangements, containing both hard law and soft law instruments, have been developed. Globally, there are more than 1,100 formal, legally binding and multilaterally negotiated “multilateral environmental agreements”. Many of these multilateral environmental agreements are also represented in Europe and Central Asia (Widerberg & Pattberg, 2015).

6.3.2.1 Global binding instruments

Even though measuring the effectiveness of binding international environmental law, i.e. treaty law, is difficult, the general trend seems to be toward greater compliance and better implementation among States over the past thirty years (Bodansky, 2015). This trend has been strengthened within Europe and Central Asia, especially in Central and Eastern Europe where “open regional funds” support a transition (GIZ, 2017). States that opt for accession to the European Union, such as Serbia, are encouraged to take necessary steps to achieve the highest levels of environmental protection and response to climate change (Heinrich-Böll-Stiftung, 2017). Potential and existing member States to the European Union need to comply with the body of European Union laws, rules and policies, including international agreements.

In general, the binding character of an international agreement seems to promote compliance, not least since States take legal commitments more seriously than political ones and therefore are more careful in negotiating and accepting them (Bodansky, 2015). However, international environmental law has been weakest when it comes to resolving major environmental challenges, such as loss of biodiversity and climate change (Bodansky, 2015; Leadley et al., 2014). Despite good examples such as the Vienna Convention for the Protection of the Ozone Layer (and the follow-up Montreal Protocol) which, through the banning of stratospheric ozone-depleting chlorofluorocarbons (CFCs), contributed to a reduction of emissions into the atmosphere (Canan, Andersen, Reichman, & Gareau, 2015; Gonzalez, Taddonio, & Sherman, 2015), there are numerous examples in which treaties have failed to achieve their stated purpose (Adam, 2010; Harrop, 2011).

This applies, unfortunately, not least to the issue of biodiversity conservation, despite efforts in the framework of the Convention on Biological Diversity (Bodansky, 2015). The Aichi Biodiversity Targets, under the Strategic Plan for Biodiversity 2011-2020 that was adopted by Parties to the Convention on Biological Diversity and recognized or supported by the governing bodies of other biodiversity-related conventions will most likely not be fulfilled in 2020 (O’Connor et al., 2015; Tittensor et al., 2014). This is considered to be a consequence of having inadequate institutional structures and governance in place, and applies equally to Europe and Central Asia.

According to the literature several reasons for protection and conservation failures can be identified (O. R. Young, 2011), where overlaps and fragmentation among the treaties are problematic. In the case of biodiversity there are, for example, seven global conventions with somewhat similar aims although with different foci; the Convention on Biodiversity, the Convention on Conservation of Migratory Species, the Convention on International Trade in Endangered Species of Wild Fauna and Flora, the International Treaty on Plant Genetic Resources for Food and Agriculture, the Ramsar Convention on Wetlands, the World Heritage Convention, and the International Plant Protection Convention (see electronic Appendix 6.1 Table 6.1.1). Although each of these “biodiversity-related conventions” has developed complementary approaches and operational tools, the treaty system remains fragmented

and when considering various contributions from nature to people, often compartmentalized. Other examples are sustainable forest management and the protection of marine and water resources, which also are covered in separate treaties or agreements, with sometimes complementary and sometimes competing objectives to those of the biodiversity-related conventions (e.g. sustainable use vs protection) (Susskind, 2008; Susskind & Ali, 2015).

Another problem characterizing the global environmental treaty-making system is the level of ratification of treaties by States (Bodansky, 2015; Koivurova, 2014). This is not a major problem within Europe and Central Asia, where almost all countries have ratified, for example, the seven global biodiversity-related conventions. A larger problem, however, concerns the fragmentation of the treaty system. The implementation of treaties in the domestic legal systems may be slow due to, for example, lack of political will or financial resources at the national level, or due to the lack of proper enforcement mechanisms (Susskind & Ali, 2015). Seventeen Sustainable Development Goals were adopted by the United Nations General Assembly as part of the “2030 Agenda for Sustainable Development” (see Chapter 5 Section 5.4.1 for a detailed description), embracing the so-called “triple bottom line” approach to human wellbeing (i.e. the combination of economic development, environmental sustainability, and social inclusion). Although non-binding, they have the potential to contribute to the reduction of the current fragmentation of the international law system by enabling synergistic interactions between existing legal instruments, the mainstreaming of biodiversity into the goals, and consistency between targets within goals at multiple levels (Oberthür & Gehring, 2006; Yoshida & Zusman, 2015).

Binding instruments at the international level are important for Europe and Central Asia as they define many of the objectives and means to protect and conserve, for instance, biodiversity. The advantages and problems related to international cooperation, such as compliance with, and enforcement of, international environmental law, apply also to the countries of Europe and Central Asia.

6.3.2.2 Regional binding instruments

Regional binding instruments are, by contrast to global treaties, limited in their geographical scope to certain regions, e.g. Europe, the Nordic countries, the Mediterranean or Central Asia. Such instruments address certain shared focal areas and objectives with respect to environmental protection, and function much in the same way that global binding instruments do, forming part of international law. For relevant agreements in Europe and Central Asia see electronic Appendix 6.1 Table 6.1.2. See also Section 6.3.3 where regional environmental instruments are addressed by theme (transboundary challenges). A significant proportion of regional binding instruments in Europe and Central Asia stems from the European Union, see further Section 6.3.2.3. As an organization, the European Union is partner to several international environmental agreements regarding the protection of the environment and biodiversity. Importantly for their enforcement, these agreements have been transformed into binding European Union law through the adoption of regulations and directives.

Although not formally a partner, the European Union coordination of sustainable spatial development is anchored by the Council of Europe Landscape Convention (Council of Europe, 2000) and applied through the Committee of Ministers of the Council of Europe, and is a convention to which many states in Europe and Central Asia are party. There are several other regional agreements, for instance concerning watercourses: the Convention on the Protection and Use of Transboundary Watercourses and International Lakes from 1992, and more detailed rules on specific water courses or lakes, have been negotiated, for example for the rivers Rhine, Elbe, Mosel and Danube as well as the water courses between Norway and Sweden and between Sweden and Finland.

The Arctic Council, established by the Ottawa Declaration in 1996 (Arctic Council, 1996), includes the following countries from Europe and Central Asia: Russia, Finland, Sweden, Norway, Iceland and Denmark (note that Greenland, although Danish territory, is assessed under the IPBES Regional Assessment for the Americas). It is distinguished by the six main indigenous people's organizations in the Arctic (two of which pertain to Europe and Central Asia, the Saami Council and the Russian Association of Indigenous Peoples of the North) that have permanent representation at the Council. The first binding agreement from the Arctic Council is the Arctic Search and Rescue Agreement from 2011, encompassing an observatory function for accidental oil spills that could impact on Arctic coastal biodiversity and fisheries. On the basis of major societal and environmental changes confronting the Arctic there is a knowledge gap with respect to what types of institutions work best to improve the well-being of Arctic residents, including what roles formal and informal institutions will play in meeting future needs (Larsen & Fondahl, 2015).

Although the bulk of regional environmental agreements in Europe and Central Asia exist in Western and Central Europe, including the environmental legislation of the European Union, the same implementation and enforcement gaps are present as seen with global international treaties (Susskind & Ali, 2015). An exception to some extent is the European Union, which has stronger enforcement mechanisms for obliging member States to comply with legislation.

6.3.2.3 The European Union and European Union environmental law

European Union law for the governance of biodiversity and nature's contributions to people is immensely important and is a role model for non-European Union countries in Europe and Central Asia. Hence, it is discussed in detail here. The key European Union institutions are the European Commission, the European Council, the Council of the European Union (the Council), the European Parliament, and the European Court of Justice (European Union, 2016c, Articles 14-19). The European Union funding treaties are the primary source of law, regulating the policy areas where the European Union can adopt secondary legislation (i.e. regulations and directives).

Implementation and enforcement are key factors for the effective application of European Union environmental law and policy (European Union, 2013a). While implementation lies foremost with the member States, the responsibility for enforcement is shared between the member States and the European Commission. While the member States are primarily responsible for providing adequate and appropriate sanctions for environmental offences, the European Commission ensures that European Union law is sufficiently implemented and applied throughout the member States. For this purpose, the European Commission may bring legal action against a member State before the European Court of Justice, where the member State risks being condemned for infringement of the obligations under the treaties (European Union, 2016b, Articles 258 and 260). The European Court of Justice therefore forms an essential part of the enforcement of the European Union legislation. There is also an informal European Union network created especially to improve enforcement, called Implementation and Enforcement of Environmental Law.

European Union environment policy under the treaties rests on the principle of integrating environmental concerns into other policy areas (European Union, 2016c, Article 11), a high level of environmental protection, the polluter pays principle, and on the principles of precaution, prevention and rectifying pollution at source (European Union, 2016c, Article 191-193). In addition, the following environmental objectives guide Union action on the environment:

- to preserve, to protect and to improve environmental quality;
- to protect human health;

- 30233 • to utilize natural resources prudently and rationally; and
- 30234 • to promote measures at international level to deal with regional or worldwide environmental
- 30235 problems, and in particular combating climate change (European Union, 2016c, Article 191.1).

30236 Together, the objectives and principles of the treaties lay the foundation for more substantial
 30237 environmental law and policy within the Union (Krämer, 2011). In the environmental field, the treaties
 30238 authorize European Union institutions to act in all sectors of European Union environmental policy
 30239 (see **Table 6.3**), i.e. climate change; protection of air, water and biodiversity; waste management; and
 30240 sustainable consumption (European Union, 2016c, Articles 191-193; Krämer, 2011). Policy decisions,
 30241 such as multiannual environment action programmes or policy decisions covering a specific sector of
 30242 European Union environment policy (e.g. the 2020 Biodiversity Strategy), provide priority objectives
 30243 and strategic guidance for more concrete environmental actions in the forthcoming years (Jans &
 30244 Vedder, 2012). The European Union has developed several horizontal strategies for the conservation
 30245 of biodiversity and restoration of ecosystems over the years, the latest being the 2020 Biodiversity
 30246 Strategy from 2011 (European Commission, 2011a). Protection, conservation and enhancement of
 30247 natural capital within the European Union is also one of the priority objectives in the 7th and latest
 30248 European Action Programme entitled “living well, within the limits of our planet” (European Union,
 30249 2013a).

30250 Binding environmental actions take the form primarily of regulations, and of directives, which create
 30251 specific legal obligations for European Union member States. The aim of regulations is to totally
 30252 harmonize member States’ legislation in a certain field, to promote integration and the proper function
 30253 of the internal market (Jans & Vedder, 2012). A directive is, instead, legally binding in terms of results
 30254 to be achieved within a prescribed time, but leaves the form and method for implementation to the
 30255 member States (European Union, 2016c, Article 288). The member States are expected to loyally
 30256 implement, interpret and apply European Union law under the principle of sincere cooperation
 30257 (European Union, 2016b, Article 4.3). The principles of subsidiarity and proportionality applied to the
 30258 environmental field mean that Union action normally is justified for environmental matters that have
 30259 transboundary effects, and that framework directives leaving implementation responsibilities to the
 30260 member States are preferred over detailed, harmonizing regulations (European Union, 2016b, Article
 30261 193, 2016c, Article 5; Jans & Vedder, 2012).

30262 Despite many institutional initiatives and strong enforcement mechanisms, also within the European
 30263 Union, poor implementation remains a fact even if compliance may vary across different policy areas
 30264 as well as within and between member States (Falkner & Treib, 2008; A Jordan, 1999; Nicolaidis &
 30265 Oberg, 2005). The European Court of Justice has also, on numerous occasions, disallowed member
 30266 State’s attempts to transpose a directive into national law for reasons of being too unclear and vague
 30267 (Krämer, 2011).

30268 **Table 6.3: Key European Union strategies and related directives. Source: (EEA, 2015e)**

Topic	Overarching strategies	Related directives
Biodiversity	Biodiversity Strategy to 2020	Birds Directive Habitats Directive Invasive Alien Species Regulation
Land and soil	Thematic Strategy on Soil Roadmap to a Resource-Efficient Europe	
Water	Blueprint to Safeguard Europe's Water Resources	Water Framework Directive Flood Risk Directive Urban Waste Water Treatment Directive Priority Substances Directive Drinking Water Directive

		Groundwater Directive Nitrates Directive
Marine	Integrated Maritime Policy including the Common Fisheries Policy and Blue Growth Strategy	Marine Strategy Framework Directive Maritime Spatial Planning Directive
Air	Thematic Strategy on air pollution	Ambient Air Quality Directive National Emission Ceilings Directive
Climate	European Union Strategy on Adaption to Climate Change 2020 Climate and energy package	Renewable Energy Directive Biomass Directive Energy Efficiency Directive

30269

30270 *6.3.2.4 Soft law instruments and capacity building*

30271 As indicated above (see 6.3.2), there is an increasing use of non-binding normative instruments instead
 30272 of, or as a complement to, legally binding international law. Soft law instruments, such as charters,
 30273 resolutions, declarations or recommendations or guidelines by the world community, have thus come
 30274 to play an important role in the growth of international norms in environmental protection. The impact
 30275 of non-binding soft law instruments should not be underestimated since they can be effective by
 30276 working indirectly, through persuasion and not coercion. Soft law often develops into a binding treaty
 30277 or by being recognized as customary law (Ahmed & Mustofa, 2016).

30278 Instead of creating rules and obligations that must be strictly followed, soft law creates goals and
 30279 aspirations that States can strive to achieve. If a State fails to achieve the environmental objectives
 30280 encompassed in a soft law document there is no recourse available or enforcement mechanism to
 30281 force compliance. Despite these weaknesses there are certain advantages compared to hard law.
 30282 While creating binding rules is often time-consuming and tends to undermine national sovereignty,
 30283 soft law instruments provide alternative means to establish relationships and partnerships. These
 30284 include more flexible solutions, which allows states to tailor their commitment to their particular
 30285 situation and find compromises which can be more easily adapted to national contexts and under
 30286 scenarios of uncertainty (Abbott & Snidal, 2000; Guzman & Meyer, 2010)

30287 Soft law is, however, dependent on effective monitoring schemes for the fulfilment of the aim of
 30288 adoption of such instruments, as well as improved financial incentives (Ahmed & Mustofa, 2016).
 30289 There is an urgent need to develop financing opportunities and mechanism for capacity building to
 30290 support the implementation of soft as well as hard law. Currently general mechanisms such as
 30291 voluntary contributions fund United Nations agencies, while multilateral development banks such as
 30292 the Global Environment Facility provide more specific funding. Capacity building can also come in the
 30293 form of programmes such as the Environmental Performance Review programme that assists countries
 30294 in the improvement of their environmental management and performance (e.g. by way of the Global
 30295 Environment Facility Trust Fund; UNECE, 2017d). Within the Arctic region the Arctic Council initiates
 30296 assessments through its six permanent working groups, all of which are more or less relevant for
 30297 biodiversity and ecosystem services, such as the Sustainable Development Working Group, the Arctic
 30298 Monitoring and Assessment Programme and Conservation of Arctic Fauna and Flora. These
 30299 assessments provide a better understanding of major issues related to sustainable human
 30300 development in the Arctic, and identify priorities and develop policies and plans to address them. All
 30301 in all, various forms of capacity building are necessary to enhance the compliance of environmental
 30302 law at regional and national level, also in Europe and Central Asia.

30303

30304 *6.3.2.5 Environmental rights approaches*

30305 Globally and regionally the link between environmental protection and human rights has been
 30306 increasingly emphasized over recent decades (Anton & Shelton, 2011; Boyle & Anderson, 1996;
 30307 Picolotti & Taillant, 2003). When it comes to human rights approaches to protecting human health or
 30308 the environment, a distinction is commonly made between substantive environmental rights (a right
 30309 to a healthy environment) and environmental rights, which are procedural in nature (Anderson, 1996).
 30310 The most prominent example of the latter is the Aarhus Convention from 1998: Convention on Access
 30311 to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters.
 30312 Within Europe and Central Asia, the European Court of Human Rights in Strasbourg has in particular
 30313 been developing the link between human rights and environmental performance under the
 30314 Convention for the Protection of Human Rights and Fundamental Freedoms from 1950. A number of
 30315 court cases, above all linking poor environmental performance by state authorities to human well-
 30316 being and health aspects, have taken place over recent years with the Lopez Ostra case in 1994 as a
 30317 starting point (Shelton, 2014; Turgut, 2007). Hence, the relevant instruments are global and regional
 30318 human rights conventions with their protocols, which emphasize basic rights such as the right to
 30319 health, property, equality, and respect for private and family life as well as binding multilateral
 30320 environmental agreements. The latter often include participatory and benefit-sharing mechanisms,
 30321 indicating participation in environmental decision-making as more or less a moral imperative (e.g., the
 30322 Aarhus Convention, Convention on Biological Diversity, the Forest principles). Such environmental
 30323 rights have thus become important policy instruments to legitimize both the procedures and outcome
 30324 of environmental policy processes (Johansson, 2013).

30325 In assessing the effectiveness of the human rights approach to environmental protection, it has been
 30326 suggested that the approach is individualistic and anthropocentric, steeped in Western philosophy and
 30327 does not adequately address the intrinsic value of the environment and ecosystems (Gearty, 2010;
 30328 Grear, 2011). The concept of participation and its practice has also been subject to significant critique
 30329 (Nabatchi, 2012; Nabatchi, Ertinger, & Leighninger, 2015; Nabatchi & Leighninger, 2015); participation
 30330 is often applied with the intent to increase efficiency or support governmental reform and
 30331 implementation and not as a component of environmental rights (Hovik, Sandström, & Zachrisson,
 30332 2010; Reimerson, 2013). Ever since the link between human rights and environmental protection was
 30333 recognized in the 1972 Stockholm Declaration, three main options to further the interaction between
 30334 human rights and environmental policies have been discussed. The first option would, based on human
 30335 rights laws, include for example a right to a clean environment. The second option would be to leverage
 30336 environmental laws, for better protection of human rights. The third option would be to fuse
 30337 environmental law and human rights (UNEP, 2012). The recently adopted Sustainable Development
 30338 Goals seem to be moving in this third direction and the implications are currently being debated among
 30339 social science scholars (C. Williams & Blaiklock, 2016).

30340 In sum, these human rights' approaches provide an alternative means to environmental and health
 30341 protection for individuals where domestic environmental regulation fails to take biodiversity and
 30342 nature's contributions to people, as well as good quality of life, into consideration. This is also relevant
 30343 in Europe and Central Asia, where the European Court of Human Rights in Strasbourg has substantiated
 30344 such approaches through case law. Moreover, this rights-based approach, with its focus on
 30345 participation and power relations and rights claimed by citizens, has the potential to contribute to
 30346 social action among indigenous peoples and local communities. The approach centres around
 30347 principles such as equality, environmental justice and the identification of how, why and to what
 30348 extent certain individuals or groups may be marginalized in formal and informal processes and actions
 30349 (Dehm, 2016). The literature does, however, emphasize the complex trade-offs that exist between
 30350 human well-being and biodiversity conservation goals (McShane et al., 2011).

30351

30352 *6.3.2.6 International standards on indigenous peoples and local communities*

30353 Over the last two to three decades the rights of indigenous peoples have been increasingly
 30354 acknowledged and strengthened within the international legal system (Åhrén, 2016; Anaya, 2004;
 30355 Xanthaki, 2009), a prominent example being the adoption of the United Nations Declaration on the
 30356 Rights of Indigenous Peoples (UNDRIP) in 2007. Indigenous peoples' international status has also
 30357 rapidly evolved from being viewed as objects of protection towards acceptance as self-governing
 30358 nations who wish to preserve their culture and ways of life (Heinämäki, 2015). Hence, indigenous rights
 30359 to self-determination, equality, non-discrimination, health and cultural matters are recognized
 30360 internationally as well as in domestic legal systems – also within Europe and Central Asia.

30361 In Nordic Europe, the Nordic Sámi are organized transnationally via the Sámi Council, while across
 30362 Central Asia there are numerous indigenous communities and the Russian Association of Indigenous
 30363 Peoples of the North is a key organization in Western and Eastern Europe. Across Europe and Central
 30364 Asia indigenous peoples and local communities represent a plethora of languages and livelihood
 30365 practices. Within the Arctic there are trends of increased indigenous empowerment and improved
 30366 local political and economic autonomy (Larsen & Fondahl, 2015). For the involvement of indigenous
 30367 peoples' organizations in the Arctic of Europe and Central Asia, see Arctic Council under Section 6.3.2.2.

30368 A specific contentious issue, in particular with respect to resource developments within indigenous
 30369 traditional areas, are the land rights of indigenous peoples, including their possession over lands and
 30370 traditionally used natural resources (Allard, 2015; Bankes & Koivurova, 2013; Gilbert, 2016). The right
 30371 to be consulted or the “free prior and informed consent” of indigenous communities (UNDRIP, Articles
 30372 19, 28, 32) are instrumental when developments impact on biodiversity, nature's contributions to
 30373 people, and good quality of life in traditional territories. The “free prior and informed consent” is a
 30374 tool used to mitigate harmful effects on a specific community and its livelihood, including uneven
 30375 power structures. Such tools rest on a notion that indigenous peoples are self-governing powers *vis-a-*
 30376 *vis* the State, i.e. based on a “nation-to-nation” approach, which is not expected for minorities within
 30377 international law (Anaya, 2004; Newman, 2014). As a result, partnerships with indigenous groups have
 30378 created co-management regimes of certain protected areas, such as the United Nations Educational,
 30379 Scientific and Cultural Organization's World Heritage site Laponia in northern Sweden (Reimerson,
 30380 2015).

30381 The traditional ecological knowledge of indigenous peoples and local communities is increasingly being
 30382 recognized in the area of conservation and sustainable use of natural resources (Hernandez et al.,
 30383 2014). Hence, international standards for environmental governance are focusing on decentralization
 30384 and local influence, promoting public participation, and stressing the important role of indigenous
 30385 peoples and local communities in natural resource and conservation governance and management
 30386 (Fauchald, Gulbrandsen, & Zachrisson, 2014; Heinämäki, 2009; Lemos & Agrawal, 2006; Lindroth &
 30387 Sinevaara-Niskanen, 2013; Reed, 2008). The Convention on Biological Diversity and its ecosystem
 30388 approach, and the “new paradigm” established under the auspices of the International Union for
 30389 Conservation of Nature, are of particular importance in this development. Article 8(j) of the
 30390 Convention, and its related provisions, stress the importance of including indigenous peoples and local
 30391 communities in nature conservation efforts.

30392 International and non-governmental organizations, not least the Convention on Biological Diversity
 30393 and the International Union for Conservation of Nature, have been fundamental to indigenous claims
 30394 (Brosius, 2004; Fourmile, 1999; Posey, 1996; Richardson, 2001; H. Schroeder, 2010). The changing
 30395 approaches towards indigenous peoples in international frameworks for natural resource and

conservation governance are largely a result of those efforts. The outcomes of the International Union for Conservation of Nature's World Parks Congresses in 2003 and 2014 were a result of the broad mobilization of indigenous peoples demanding that protected areas recognize their rights, responsibilities, and contributions to conservation (Brosius, 2004; Stevens, 2014).

Indigenous peoples' organizations, however, continue to criticize international authorities for failing to fulfil their targets and obligations to indigenous peoples (Forest Peoples Programme, 2008, 2011, IIFB, 2006, 2008, 2010, 2012, 2014). Traditional power structures and conservation ideals are still present in protected area policy and practice (Benjaminsen & Svarstad, 2010; Sandlos, 2014; Wilshusen, Brechin, Fortwangler, & West, 2002), and national and local implementation of international standards often proves challenging (Benjaminsen & Svarstad, 2010; Koivurova & Heinämäki, 2006; Lane, 2003; Lane & Corbett, 2005; Minter, van der Ploeg, Pedrablanca, Sunderland, & Persoon, 2014; Paulson, Laudati, Doolittle, Welsh-Devine, & Pena, 2012; H. Schroeder, 2010). Furthermore, indigenous peoples are largely left outside the development of treaty texts and the implementation of the treaties and, when included, they are often considered only holders of traditional knowledge. This risks reproducing discourses or ideas prioritizing conservation objectives over indigenous rights and reducing the ways indigenous peoples may influence the decision-making within the context of international treaties (Agrawal, 1995; Berkes, 2009; Berkes, Colding, & Folke, 2000; Reimerson, 2013; Turi & Keskitalo, 2014). This is also important for Europe and Central Asia with its different indigenous peoples and local communities and their varying historical legacies.

6.3.2.7 Information-based instruments building on private and business initiatives

There is increasing recognition of the need to enhance the use of economic instruments, such as market-based incentives, to complement traditional regulatory policy instruments at the international as well as national level. This is justified in assuming that such instruments are more efficient than traditional regulatory instruments, in particular when it comes to the implementation of multilateral environmental agreements. However, with the exception of payments for ecosystem services schemes, the adoption of economic instruments has mainly been advocated in developed countries, while their uptake in developing countries and countries in transition has been limited. This can partly be explained by the lack of capacity, in these countries, to design and implement economic instruments due, for example, to unclear property rights (Karsenty & Ongolo, 2012). Yet, the increasing uptake of economic instruments in the global environmental arena has opened up for various forms of sustainability standards, such as certification schemes, voluntary corporate initiatives, public-private partnerships, and transparency-based reporting schemes (Cashore, 2002; Derkx & Glasbergen, 2014; Glasbergen et al., 2007; Gulbrandsen, 2014; Johansson, 2014).

In particular, voluntary and market-based certification schemes have emerged as innovative and dynamic institutions for non-State governance. Various certification schemes have been proposed and the number have grown rapidly over the last two decades. This has been largely in response to public failures to halt deforestation, depleting fish stocks (Gulbrandsen, 2010), and unsustainable production and consumption of a variety of commodities (Auld, Gulbrandsen, & McDermott, 2008), and certification has become an institutionalized governance approach to sustainable development (Visseren-Hamakers et al., 2012). Today, consumers encounter organic or fair-trade labels on a variety of products, implying improved environmental conditions or more equitable market transactions (Auld, 2014).

Although such initiatives have been driven by private institutions, evidence suggests that the regulatory system and the political and administrative culture have influenced their adoption in

different countries. This implies that the legal, socio-economic and political contexts may facilitate or hinder successful implementation in different sectors. For successful implementation, well-functioning legal systems and property rights must work, especially since private instruments are supposed to supplement, not replace, domestic legislation and enforcement (Gulbrandsen, 2010). Consequently, private instruments may not enhance the overall protection of natural resources in regions where government institutions are weak. At the same time, other aspects are also important here, such as the size and structure of the industry in the specific country, ownership of the resource (private vs public), and export dependence (Cashore, Auld, & Newsom, 2004).

Analyses of previous research on various private social and information-based instruments confirm this picture, but show a relatively uneven distribution of uptake and effectiveness in different sectors (Auld, 2014; Gulbrandsen, 2010; Pirker, Mosnier, Kraxner, Havlík, & Obersteiner, 2016; Visseren-Hamakers, Brondizio, Leemans, & Solecki, 2015), and considerable variability among the social and distributive impacts of these instruments (Biermann & Gupta, 2011; Schouten & Glasbergen, 2012). For instance, certification schemes are important private alternatives, not least for the formulation of forest policies to halt deforestation, and such initiatives have received significant scholarly attention. One of the most well-known examples, the stakeholder-driven Forest Stewardship Council – attentive also to indigenous rights – has to date certified 48.2% of total FSC-certified area (94,389,400 ha) in Europe and Central Asia (FSC, 2017). Despite the considerable academic attention they have received, the sustainability impacts of forest certification standards, in terms of tangible change on-the-ground, is largely unknown (Johansson, 2013; Visseren-Hamakers et al., 2015; Visseren-Hamakers & Pattberg, 2013).

6.3.3 Responses to transboundary environmental challenges

This section examines challenges related to the governance of ecosystems and the implementation of ecosystem-based management approaches across country boundaries and provides examples of regional cooperation. The focus is on broad ecosystem types and issues: groundwater and freshwater degradation and restoration, marine and coastal ecosystems, and invasive species. Each issue is examined under the headings, where relevant, of binding legal instruments, environmental rights approaches, soft law instruments and capacity building, and intergovernmental organizations. For responses to transboundary environmental challenges related to land degradation, we refer to the global IPBES Assessment on Land Degradation and Restoration, in particular Chapters 6 and 8 and the recently published reports of the Economics of Land Degradation Initiative (ELD Initiative, 2015a, 2015b). One regional report of the latter initiative has been dedicated to a synthesis of national studies in Central Asia (Quillérou et al., 2016).

6.3.3.1 Groundwater and freshwater degradation and restoration

Groundwater and freshwater degradation processes are not constrained by national boundaries and are affected by cross-boundary policies and activities. This obligates cooperation and coordination in matters of natural resource management. Nevertheless, such collaborations are not very common (Saunders & Briggs, 2002). The capacity of freshwater systems for nutrient cycling and nutrient removal is particularly valuable in Europe because of the heavy pressure placed on water by human populations (Chapter 2 Section 2.2.1.7). At present, surface and groundwater availability is expected to decrease in many countries due to changing precipitation patterns and higher evapotranspiration (Chapter 5 Section 5.2.3.2). This trend will endanger habitats that depend on surface water dynamics,

30485 whereas those dependent on groundwater dynamics and water balance would be more buffered
30486 against hydrological stress (Chapter 5 Section 5.6.1).

30487

30488 6.3.3.1.1 Binding legal instruments

30489 Challenges with regard to water resources in Europe and Central Asia call for integrative transboundary
30490 cooperation. In Central, Eastern and Western Europe such efforts mainly rely on implementation of a
30491 number of policies and practices, including water pricing, efficient use of water, action against illegal
30492 water abstraction, measures to promote restoration and sustainable development (EEA, 2000, 2010).
30493 While in Central Asia, efforts rely merely on the principle of sustainability applied conjunctly by local
30494 governments and the coordinating support of international regulatory programs (GIZ, 2013; GWP,
30495 2014). However, constrained public human and financial resources dramatically limit the
30496 implementation of multilateral environmental agreements, which is thus heavily dependent on
30497 external cooperation and support (e.g. ERP Tajikistan, UNECE, 2012).

30498 Nonetheless, in Central Asia the World Heritage Convention (and possibly Ramsar Convention) has
30499 been used to prevent transboundary impacts (e.g. impacts from hydropower planned in Mongolia on
30500 Lake Baikal in Russia (UNESCO, 2017). Both conventions include special provisions guiding parties on
30501 how to prevent damage to designated sites in other countries (World Heritage Committee, 2016).
30502 Southern Caucasus countries have also signed conventions on watershed management, and while a
30503 report from the Global Water Partnership noted that a focus on integrated water resource
30504 management is not generally applied in the Caucasus, the water sectors in many of the countries are
30505 undergoing reform and new legislative water codes have been developed (GWP, 2014)

30506 The importance of joint management of transboundary rivers and lakes to address water resource
30507 shortage and deterioration has long been recognized by governments. One of the oldest examples of
30508 an intergovernmental agreement to manage joint water bodies is the Albufeira Convention that dates
30509 from the 18th century. Nonetheless, it was not until 1992 that joint international governance
30510 mechanisms in United Nations Educational, Scientific and Cultural Organization regions were
30511 established, leading to the establishment of the Convention on the Protection and Use of
30512 Transboundary Watercourses and International Lakes (also known as the Water Convention), which
30513 protects and ensures the quantity, quality and sustainable use of transboundary water resources
30514 through facilitated cooperation. Conservation and restoration of freshwater ecosystems is a specific
30515 obligation under this convention, which requires parties to take “all appropriate measures” to this end,
30516 including the establishment of water-quality objectives and criteria, and the development of concerted
30517 action programs for the reduction of pollution. This convention has currently 42 signatories from
30518 Europe and Central Asia, but Kyrgyzstan, Tajikistan, Kazakhstan, Georgia and Turkey have not yet
30519 ratified it, due mostly to historical conflict issues (UNECE, 2011). Despite the fact that the status of
30520 these waters is now improving, transboundary water resources remain “*under great stress as a result
30521 of poor management practices, pollution, overexploitation, unsustainable production and consumption
30522 patterns, hydromorphological pressures, inadequate investment in infrastructure and low efficiency in
30523 water use*” (UNECE, 2011).

30524 The European Union Water Framework Directive (Directive 2000/60/EC; European Community, 2000)
30525 was established to contribute to the implementation of community obligations under international
30526 conventions on water protection and management, notably the 1992 Water Convention. The river
30527 basin approach and the focus on ecology and sustainable use of water are the core innovative aspects
30528 of this directive. A similar focus is also to be seen in the Floods Directive (2007/60/EC; European Union,
30529 2007b).

The basin approach is applied for the protection of groundwater in about 600 transboundary aquifers, against pollution and deterioration, under Directive 2006/118/EC (European Union, 2006). This Directive establishes specific criteria for the assessment of good groundwater chemical status and criteria for the identification and reversal of significant and sustained upward trends and for the definition of starting points for trend reversals. This directive also complements the provisions preventing or limiting inputs of pollutants into groundwater already contained in the European Union Water Framework Directive, and aims to prevent the deterioration of the status of all bodies of groundwater.

The European Union Water Framework Directive, Article 3.4, stipulates a general obligation for the member States to cooperate. However, it does not prescribe any concrete instruments to shape this cooperation, nor does it provide exemptions in case of not achieving the results by a member State because of certain acts or omissions of another member state (Gilissen et al., 2010). This often leads to problems between member States that have different systems and governmental responsibilities for water management.

6.3.3.1.2 Environmental rights approaches

The right to drinkable freshwater was first suggested as a binding law in the World Summit on Sustainable Development in Johannesburg in 2002 and was also a target in the Millennium Development Goals (Scanlon, Cassar, & Nemes, 2004) and now the Sustainable Development Goals. The environmental rights to terrestrial systems are mainly allocated to indigenous communities as defined by the United Nations Human Rights Office as “rights to their lands, territories and resources” (UNOHCHR, 2013). Under this perspective the natural habitat of indigenous people should also be preserved, except when the indigenous community is overexploiting their natural habitat (Kaapcke, 1994; Mustonen, Shadrin, Mustonen, & Vasiliev, 2011; Roberts, 1992).

Rights of indigenous peoples and local communities to subsistence use of lands and natural resources, including subsistence fisheries, have been widely recognized in resource management systems of the northern parts of the Europe and Central Asia region. Presently, however, these rights are being reduced due to, for example, progressive resource privatization and increased population pressure (Simonov & Simonova, 2016).

6.3.3.1.3 Soft law instruments and capacity building

Although scientific research on transboundary preservation issues is fairly comprehensive, the actual implementation of management recommendations is commonly hindered by the absence of funding mechanisms. In addition, the definition of freshwater and its restoration are subjects of debate, even among researchers and organizations, with consequent implications for the development of common policy options (McDonald, Gann, Jonson, & Dixon, 2016).

The Central Asia subregion has a well-established, although limited, legal framework for inter-State cooperation in the management and use of transboundary water. From a legal point of view, it includes both binding instruments and numerous semi-formal arrangements and documents that are merely recommendations, i.e. soft-law instruments. Regional agreements of a general nature are in place, as well as several bilateral agreements on practical issues relating to specific watercourses or areas of interaction. However, the river-basin approach is not reflected in the existing agreements. The legal framework does not properly establish the hierarchy and mechanisms for the coordination and collaboration of the existing institutions, does not clearly delineate their competence and does not pay

30574 sufficient attention to reporting procedures, decision-making processes, implementation and
 30575 enforcement (UNECE, 2011). A testing time for existing mechanisms came in 2016 when Kyrgyzstan
 30576 suspended its participation in the International Commission for Sustainable Development, as Tajikistan
 30577 started to build a major hydropower dam (Rogun HPP) without consent of downstream countries. This
 30578 signifies that existing arrangements are subject to amendment and that some of the transboundary
 30579 water management regimes may deteriorate due to divergent interests of parties.

30580 Transnational cooperation on ecosystem-related topics is important for defining problems, obtaining
 30581 information, and pursuing joint solutions. Examples include the prevention of water pollution in
 30582 Russia-Mongolia and Russia-China relations (see electronic Appendix 6.2 Table 6.2.1) in the context of
 30583 the Amur River basin. However, despite Amur's importance for biodiversity, fisheries and food
 30584 production, wetlands conservation or climate change adaptation, international treaties that have been
 30585 signed to date have not been able to provide a solid basis for a holistic river basin management. It has
 30586 been argued that the health of river ecosystems is yet to become a real practical priority in bilateral
 30587 water management agreements and management efforts in Central Asia (Simonov & Egidarev, 2017).

30588

30589 6.3.3.1.4 Intergovernmental organizations, programs and projects

30590 An example of project facilitation across intergovernmental organizations is the World Bank and its
 30591 Global Environment Facility, which promotes the Central Asia Transboundary Biodiversity Project,
 30592 between Kyrgyz Republic, Kazakhstan and Uzbekistan. The United Nations Economic Commission for
 30593 Europe is also engaged in transboundary regions preservation, within its regional dialogue and
 30594 cooperation on land and water resources in Central Asia; aimed in particular at the Alazabi/Ganyykh
 30595 basin and the Syr Darya (Aral Sea) Basin (UNECE, 2015c). A similar programme for the Isfra river basin
 30596 is being coordinated by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH,
 30597 which is synchronizing bilateral transboundary preservation operation between the Kyrgyz Republic
 30598 and Tajikistan with the financial support of the European Union (GIZ, 2013).

30599

30600 6.3.3.1.5 Private/business initiatives

30601 A recent report of the Economics of the Land Degradation initiative highlighted the fact that the returns
 30602 from sustainable land management are realized through the use of robust economic valuation
 30603 methodologies (ELD Initiative, 2015b). Those returns are provoking the private sector to promote
 30604 economic growth, food security and sustainable livelihoods and to reduce conflict over natural
 30605 resources. The scope of institutions set up at the river basin often includes groundwater management,
 30606 in particular where aquifer boundaries do not follow the boundaries of the river basin. Where
 30607 groundwater does not follow a particular river basin, a water framework plan is assigned with
 30608 integrated valuation to the nearest or most appropriate river basin. Less frequently, a mechanism is
 30609 set up specifically at the aquifer level concerning potential trade-offs and power relations (Mechlem,
 30610 2016).

30611 Transboundary associations of non-governmental organizations' activists and experts identify and
 30612 draw attention to transboundary ecosystem degradation problems and policy solutions are illustrated
 30613 by the recent report on integrated flood management options prepared by several non-governmental
 30614 organizations and expert bodies for the transboundary Amur River Basin published by the World Wide
 30615 Fund for Nature (Simonov, Nikitina, Osipov, Egidarev, & Shalikovsky, 2016a, 2016b).

30616 There is a widely recognized gap in existing regulations on spatial planning of industrial activities,
 30617 especially in a transboundary context. Often industrial facilities (such as hydropower plants, cement

plants or coal mines) are placed at inappropriate locations where they cause huge damage to biodiversity and ecosystem services. Strategic assessments of sectoral development schemes and programs are often employed to direct development away from sensitive areas. A good example of this is the strategic assessment of basin-wide hydropower impacts performed jointly by companies and non-governmental organizations for the Amur River Basin (Simonov, Menshikov, Egidarev, & Nikitina, 2015, see also Section 6.5.4).

6.3.3.2 Marine and coastal systems

Transboundary issues are particularly relevant for marine and coastal ecosystems where processes can impact huge areas that do not adhere to any clear political or administrative boundaries. An essential feature of ecosystem-based management is that account is taken of aggregate pressures and impacts rather than just analyzing individual pressures and impacts in isolation. This also implies conducting the analysis across an entire ecosystem's range rather than just for parts of it (i.e. instead of within member State political boundaries). As pointed out by the European Environment Agency (EEA, 2015d), it is a significant challenge to properly account for cumulative pressures and impacts across such large areas, especially because not accounting for these cumulative pressures and impacts poses tremendous risks to adequately assessing ecosystem health and safeguarding key ecosystem services.

This fact is recognized by the existence of a number of regional seas conventions and international organizations that monitor the status of the marine environment and the level of pressures from different sectors or sources, on regional marine and coastal ecosystems. The following section outlines the major instruments and approaches employed to facilitate cross-border protection of marine ecosystems and the transboundary challenges that need to be overcome in order to facilitate more effective governance and protection.

6.3.3.2.1 Binding legal instruments

The key binding legal instrument in the European Union aimed at formalizing an ecosystem-based approach to marine environmental management is the European Union Marine Strategy Framework Directive. It is important from a transboundary perspective as it specifically requires regional and transboundary cooperation (European Union, 2008, Article 5.2). Article 10 also specifically refers to the Regional Sea Conventions: "*Member States shall take into account the continuing application of relevant existing environmental targets laid down at national, community or international level in respect of the same waters, ensuring that these targets are mutually compatible and that relevant transboundary impacts and transboundary features are also taken into account, to the extent possible*". In addition to the European Union Marine Strategy Framework Directive, the European Union's Maritime Policy Action Plan recognizes that efforts to coordinate current sectoral policies require integrated and cross-cutting actions that operate across national boundaries. The action plan recognizes the fact that an integrated maritime policy requires a governance framework that applies the integrated approach at every level, as well as horizontally and with the use of cross-cutting policy tools.

There are a number of key conventions aimed at fostering transboundary marine protection in Europe and Central Asia (see electronic Appendix 6.2 Table 6.2.2). The regional seas conventions have demonstrated that it is possible to develop an integrated ecosystem assessment on a regional scale. The Baltic Marine Environment Protection Commission (HELCOM, 2010), for example achieved this under the Helsinki Convention by harmonizing and combining maps of ecosystem features with maps

of pressures resulting from human activities in a combined spatial analysis that crosses national jurisdictions. This allowed for a spatial description of the relative impacts of human activities across the Baltic Sea (Figure 6.3).

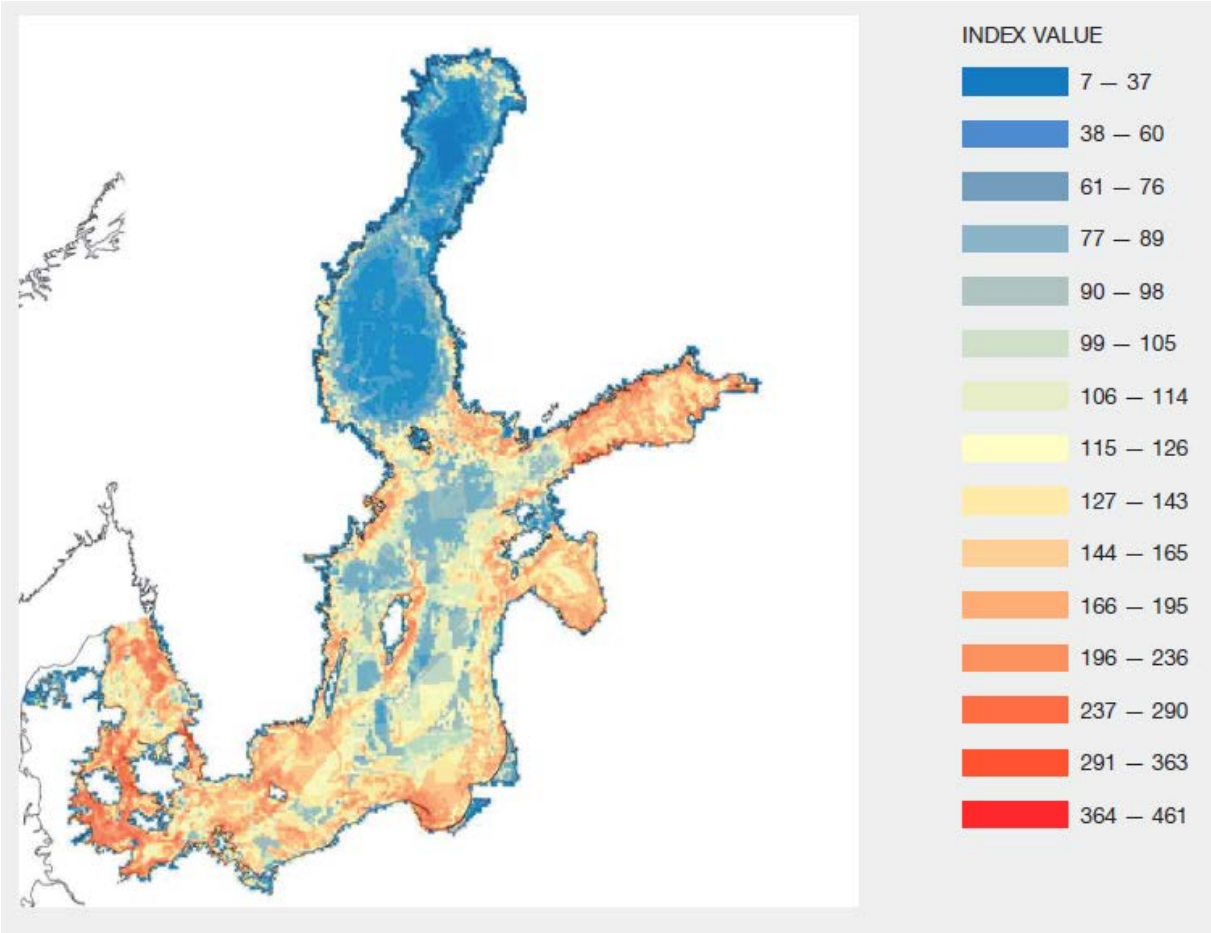


Figure 6.3: Baltic Sea Impact Index (BSII) showing the potential impact of anthropogenic pressures (HELCOM, 2010)

The Regional Seas Conventions have been seen to be successful in the joint management and conservation of large marine areas, but an early report by the United Nations Environmental Programme on their success did warn that “In many regions the level of expertise and facilities available for the actual implementation and conduct of the agreed action plans is limited” (UNEP, 1982). More recently Mackelworth (2016) notes that while modern conservation principles are explicitly incorporated or implicitly applied under the relevant regional instruments, they still require further operationalization and consistent application by all organizations and countries involved. Rochette and Chabason (2011) also highlighted the differences in regional arrangements and fragmented international governance in limiting the success of the conventions. An assessment of management effectiveness by Van Lavieren and Klaus (2013) revealed variable levels of performance across the members and the authors recommended the adoption of the Regional Protocol on Biological Diversity and Specially Protected Areas.

6.3.3.2.2 Soft law instruments and capacity building

Softer forms of international cooperation for the joint management and conservation of the seas include the Trilateral Wadden Sea Cooperation. Since 1978, the Netherlands, Germany and Denmark

have cooperated to protect the Wadden Sea as an ecosystem. The guiding principle of the Trilateral Wadden Sea Cooperation is to *“achieve, as far as possible, a natural and sustainable ecosystem in which natural processes proceed in an undisturbed way”*. The Cooperation is based on the “Joint Declaration on the Protection of the Wadden Sea”, which was first signed in 1982 and then updated in 2010. The Joint Declaration is a declaration of intent, including objectives and areas of cooperation, as well as institutional and financial arrangements. For over 30 years, the Cooperation has united partners from politics, nature conservation, science and administration, along with local stakeholders, who together represent an enormous store of knowledge and experience. It is a unique example of effective transboundary ecosystem-based collaboration to jointly conserve a World Heritage site (Common Wadden Sea Secretariat, 2017).

Through its European Neighbourhood Policy, the European Union works with its southern and eastern neighbours to achieve the closest possible political association and the greatest possible degree of economic integration. The European Neighbourhood Policy is a key part of the European Union's foreign policy. Partner countries have agreed on a European Neighbourhood Policy action plan or an Association Agenda with the European Union demonstrating their commitment to, amongst other issues, environmental protection and sustainable development. In particular, this intergovernmental policy seeks to strengthen marine environment protection across borders with the European Union by *“better preserving shared natural resources and improving conditions for fisheries”* and by ensuring *“the protection of shared seas and river basins”*. The European Neighbourhood Policy is a jointly owned initiative and its implementation requires action on both sides, by the neighbouring state and by the European Union. There are currently 16 neighbouring states involved including, Jordan, Israel, Georgia, Armenia and Azerbaijan (Wesselink & Boschma, 2017).

6.3.3.2.3 Private and business initiatives

The use of ecolabels and certificates of sustainability may be an effective means of promoting more sustainable practices in shared marine waters for wild-captured fisheries, but also for the aquaculture industry. Companies may also employ instruments other than eco-labels such as green procurement (Runhaar, 2016). According to estimates, there are over 400 existing ecolabels marking consumer products worldwide (Golden et al., 2010). The marine-based ecolabels tend to certify sustainability of caught or farmed marine seafood. For example, Unilever and the World Wide Fund for Nature joined forces in 1997 to create the Marine Stewardship Council. The Council is a non-profit organization that has developed a global environmental standard for sustainable fishing. Some of the standards measured by the Marine Stewardship Council (MSC) include the maintenance of sustainable fish populations and the minimization of environmental impacts. At present, 286 certified fisheries can be found in 36 countries, accounting for 10% of all global catch, (92 still in assessment) and there are 37,121 sites with chain-of-custody certification which assures consumers and seafood-buyers that MSC-labelled seafood comes from a certified sustainable fishery (Marine Stewardship Council, 2016). Although overfishing and depletion of global fish stocks continue, there are indications that, in Marine Stewardship Council-certified fisheries, some improvements are being made in fisheries management and practices (Agnew, Gutierrez, Stern-Pirlot, & Hoggarth, 2014; Gulbrandsen, 2010).

6.3.3.2.4 Assessment of transboundary challenges in marine and coastal areas

Hanley and co-authors (Hanley, Hynes, Jobstvogt, & Paterson, 2015) point out that the integration of economic and biophysical ecosystem service valuation into marine policy formation remains challenging due to the fact that these ecosystems tend to be large, and often overlap multiple political

jurisdictions. The authors also point to the fact that, even in the European Union, where an integrated institutional framework exists for the governance of regional seas in the form of the Marine Strategy Framework Directive, member States have not yet been able to collaborate in an effective manner at the regional seas level when carrying out the assessment work that is a requirement of the Directive. Elsewhere Oinonen and co-authors (Oinonen et al., 2016) point out that several of the descriptors of “good environmental status” under the Marine Strategy Framework Directive are already regulated by existing legislation and recommend that economic analysis for the implementation of the Marine Strategy Framework Directive should place particular emphasis on those descriptors that are not covered by any other piece of legislation, such as underwater noise and marine litter.

The political commitment to cooperative management by the Governments of countries bordering regional seas is a fundamental requirement for success of any agreements aimed at the implementation of environmental protection measures. This regional cooperation translates into the meaningful exchange of information across countries. Many marine ecosystems and the environmental pressures and impacts acting upon them are transboundary in nature. Therefore, the information and databases needed to identify these pressures must cover all of the ecosystems in question rather than the parts of it that lie within a country’s border.

It is also recognized that the effective management of marine ecosystems requires the use of cost-benefit analysis and cost-effectiveness analysis to ensure the sustainable use of marine resources (European Union, 2008, Article 8). These economic tools can also help to identify cost-effective approaches and abatement options to protect or restore the provision of marine ecosystem services. It has been pointed out elsewhere (Oinonen et al., 2016), however, that if cost effectiveness analysis were to be carried out at the regional seas level, more cost effective abatement alternatives may present themselves that might not be obvious at the individual member State level. This could result in more cost-effective alternatives being chosen to achieve the environmental goals.

It is worth noting that a report by the United Nations Development Programme (UNDP, 2015) points out that starting regional cooperation initiatives in geographical areas with little experience of an inter-State cooperation requires a discussion of possible institutional models of the future interstate regional cooperation to be developed. It gives the example of the Aral Sea Basin where many regional cooperation organizations operate with rules and procedures that are a mix of the approaches from the former Soviet centralized system and are partly based on the principles of the cooperation between the independent States. Ultimately, the success of any transboundary conservation instrument will depend on the effective collaborate of the bordering parties.

6.3.3.3 *Invasive alien species*

Invasive alien species are a major concern within Europe and Central Asia. However, their control is complex and, in many cases, difficult to handle with legal instruments. This situation is reflected in a vague text on invasive alien species from the thirteenth meeting of the Conference of the Parties to the Convention on Biological Diversity in Cancún, Mexico (CBD, 2016a). Achieving Aichi Biodiversity Target 9 on preventing and controlling invasive alien species is likely to be a considerable challenge.

Trade and transport are important factors affecting the introduction and spread of invasive alien species (Hulme, 2009; Pyšek et al., 2012), with the amount of exchanged commodities expanding more than 30-fold since 1950 (WTO, 2013). In addition to the direct effects of trade on the spread of invasive alien species, new transport corridors and enlarging of existing ones supports an upsurge of introductions. The Suez Canal recently underwent a major enlargement (Suez Canal Authority, 2016), and the expansion of the Panama Canal was intended to double its capacity and transit vessels three

times as big as possible in 2015. A third canal may also be built, across Nicaragua. While global trade and shipping are vital to society, existing international environmental agreements also recognize the urgent need for sustainable practices that minimize the unwanted impacts and long-term consequences of bio-invasions – these are essentially transboundary issues.

6.3.3.3.1 Binding legal instruments

The need to tackle biological invasions, to develop a common policy and to establish an early warning system, has been recognized at European Union level, for example by the European Commission (i.e. Communication “Towards an EU Strategy on Invasive Species”, (European Commission, 2008) and EU Biodiversity Strategy to 2020. Other instruments recognizing the spread of invasive alien species are listed in **Table 6.4**.

Table 6.4: Instruments for addressing invasive alien species. Source: Own representation.

Policy area	Instrument Title	Responsible Institution	Description
European Union	The Habitats Directive	European Commission	Directive 92/43/EEC lists over 1,000 animal and plant species, as well as 200 habitat types under protection. Its sole mention of non-native species pertains to provision for supplementary measures to govern their possible introduction.
Mediterranean Sea	Barcelona Convention	United Nations	Adopted in 1976, amended in 1995 and came into force on 9 July 2004. An Action Plan concerning species introductions and invasive species in the Mediterranean Sea was adopted in 2003 (“UN Environment Regional Seas,” n.d.).
Western, Central and Eastern Europe	Bern Convention	Council of Europe	The Standing Committee of the Bern Convention recommended in 2003 that Contracting Parties implement national strategies on invasive alien species and co-operate in the prevention, mitigation and eradication of invasive alien species, where feasible and practical.
European Union	European Union Regulation 1143/2014 on Invasive Alien Species	European Commission	Entered into force January 1st 2015. It is an important instrument setting out the provisions and responsibilities concerning invasive alien species of Union, regional and Member State concern
Mediterranean	The Barcelona Convention	European Commission	The convention provides seven protocols to address specific aspects of Mediterranean environmental conservation including marine biological diversity and pollution from exploration and exploitation offshore.
European seas	European Union Marine Strategy Framework Directive	European Commission	Acknowledges the critical role of vectors in biological invasions and consider it crucial to manage the pathways.
Caspian Sea	Ballast Water Management Convention	International Maritime Organization	Under the Convention’s terms, ships will be required to manage their ballast water to remove, render harmless, or avoid the uptake or discharge of aquatic organisms and pathogens within ballast water and sediments. However, IMO’s guidelines for the control and management of ships’ biofouling, is voluntary.

Many countries in Europe and Central Asia have only scattered legislative or advisory tools (e.g. codes of conducts; (Caffrey et al., 2014; Halford et al., 2014; Heywood & Brunel, 2011). The United Kingdom is the exception with its invasive non-native species strategy and dedicated secretariat.

30791 6.3.3.3.2 Soft law instruments and capacity building

30792 Several bodies serve in an advisory capacity concerning monitoring, research and management of alien
 30793 species across national boundaries at both global and regional levels. These include the European
 30794 Environment Agency and the European Invasive Species Specialist Group of the International Union for
 30795 Conservation of Nature. At the international level, there is a long-lasting cooperation in the field of
 30796 phytosanitary, veterinary and pest management regulatory principles through the European Plant
 30797 Protection Organization, European Food Safety Authority and the United Kingdom Department for
 30798 Environment, Food and Rural Affairs. Similarly, these agricultural branches have efficient domestic
 30799 regulations based on a long history leading to effective monitoring and management of pests.

30800 Present national and regional inventories of alien species are heterogeneous in terms of their spatial,
 30801 temporal and taxonomic coverage as well as their accuracy. At continental level notable datasets
 30802 include the European Network on Invasive Alien Species (NOBANIS, 2017) or *Delivering Alien Invasive*
 30803 *Species Inventories for Europe* (DAISIE, 2017). The new European Union invasive alien species
 30804 regulation calls for a centralized information system collating the existing information on alien species
 30805 in the Union and allowing access to information on the presence of species, their spread, ecology,
 30806 invasion history and all other information available. This was partly achieved by *Delivering Alien*
 30807 *Invasive Species Inventories for Europe*, which initiated the collection of data from adjacent non-
 30808 member States and less developed countries. Recently, a data aggregating portal linking some existing
 30809 national and continental sources was constructed through The European Alien Species Information
 30810 Network (EASIN, 2017).

30811 The recent meeting of the Contracting Parties to the Convention for the Protection of the Marine
 30812 Environment and the Coastal Region of the Mediterranean and its Protocols (Barcelona Convention)
 30813 adopted an action plan and monitoring and assessment programme that ostensibly deals with non-
 30814 indigenous and invasive species (UNEP, 2016a, 2016b). Though replete with expressions of concern for
 30815 the Mediterranean marine environment, neither document deals with the most significant pathway
 30816 and the majority of the invasive alien species.

30817 The spread of invasive alien species along trade routes such as the “new silk road” which, if successful,
 30818 may soon triple or quadruple trade in Europe and Central Asia, is expected to lead to accelerating
 30819 biological invasions (Ding, Mack, Lu, Ren, & Huang, 2008; Zhang & Jiang, 2016). Responding to these
 30820 developments, the China Ministry of Environment already started research on possible ways to control
 30821 the spread of invasive or exotic species in the region in 2015. Given that great numbers of marine and
 30822 terrestrial invasive species may come to Europe and Central Asia from East Asia this is considered a
 30823 timely effort that may need focused international cooperation in the realm of the Shanghai
 30824 Cooperation Organization, China-European Union cooperation and other multilateral platforms.

30825

30826 6.3.3.3.3 Assessment of challenges related to Invasive Alien Species

30827 Current legislative and management efforts have failed to address the introduction and spread of
 30828 invasive alien species in terrestrial, inland aquatic and marine environments across Europe and
 30829 neighbouring regions for a number of reasons (Galil, Marchini, & Occhipinti-Ambrogi, 2016; García-de-
 30830 Lomas & Vilà, 2015; Genovesi, Carboneras, Vila, & Walton, 2015; Hulme, 2009):

30831 1) The European Union invasive alien species regulation should focus on preventive actions concerning
 30832 vectors and pathways of introductions, in addition to control and mitigation measures of significantly-
 30833 impacting invasive alien species already present.

30834 2) International cooperation is insufficient.

- 30835 3) Transboundary impacts of man-made corridors of introduction are neglected.
- 30836 4) Transfer of best practice management in dealing with invasive alien species lacks support (e.g. use
30837 of chemical treatment).
- 30838 5) Border control is limited.
- 30839 6) Timely information exchange of invasive alien species distribution and their impacts is lacking.
- 30840 Mediterranean countries have not taken sufficient measures to address biosecurity hazards relating
30841 to movement of stock, feed, and equipment that may result in the introduction of marine invasive
30842 alien species (CIESM, 2007; Golani, Sonin, & Rubinstein, 2015; Marchini, Ferrario. J, & Occhipinti-
30843 Ambrogi, 2016) or illegal introductions. The appearance of five non-indigenous prawn species in the
30844 Mediterranean, all of commercial interest and newly recorded in the past decade, suggest intentional
30845 introduction, particularly as these species have been found in the vicinity of fish and shellfish farms.
30846 The European Union established a legal framework to limit the environmental risks related to the
30847 introduction and translocation of non-native species in aquaculture (European Union, 2007a) but, as
30848 it pertains only to member States, and is unevenly regulated even in those countries, illegal
30849 introductions and intra-national translocation of shellfish stocks (and their associated biota) continue
30850 to contribute to the introduction and spread of marine invasive alien species in the Mediterranean Sea
30851 (Bakir & Aydin, 2016).

30852

30853 **6.4 Environmental and conservation policies in Europe and Central Asia**

30854 **6.4.1 Policies for biodiversity and nature conservation**

30855 **6.4.1.1 Policy objectives**

30856 Nature conservation and biodiversity policy objectives usually relate to the following four major areas:
30857 i) the conservation of nature and biodiversity; ii) the sustainable use of biological resources; iii) the fair
30858 and equitable sharing of the benefits from the use of genetic resources; and iv) the restoration of
30859 degraded ecosystems. Although these objectives are at first sight policy objectives of the conservation
30860 sector only, mainstreaming the conservation and sustainable use of biodiversity into national sectoral
30861 and cross-sectoral strategies, policies, plans and programmes is a priority of both international and
30862 European Union biodiversity strategies (European Commission, 2011a; Secretariat of the CBD, 2011).
30863 This section will address the first and, to some extent, the third objectives, while sustainable use will
30864 be dealt with in Section 6.5, especially agriculture, forestry and fisheries. The fourth objective,
30865 ecosystem restoration, is becoming ever more important due to unabated land-use intensification and
30866 land degradation in many parts of Europe and Central Asia (see Chapter 4, Section 4.5). As this topic is
30867 comprehensively assessed in the IPBES Land Degradation and Restoration Assessment (see Chapters 6
30868 and 8 for response options), it is only shortly addressed here (see also Quillérou et al., 2016, for a
30869 synthesis on the economics of land degradation for Central Asian countries).

30870 In Europe and Central Asia, nature and biodiversity conservation activities are embedded in a complex
30871 network of international and regional objectives and targets. At the international level, several
30872 biodiversity-related conventions and strategies promote the implementation of the Convention on
30873 Biological Diversity (CBD, 2010), such as the Ramsar Convention, the Convention on International
30874 Trade in Endangered Species of Wild Fauna and Flora or the Convention on the Conservation of
30875 Migratory Species of Wild Animals (see Section 6.3 and electronic Appendix 6.1, Table 6.1.1 on
30876 Multilateral Environmental Agreements). The United Nations Strategic Plan for Biodiversity (2011 –
30877 2020) includes the 20 Aichi Biodiversity Targets to promote the implementation of the Convention on

Biodiversity. These targets cover the protection of biodiversity from anthropogenic pressures, the distribution of benefits from biodiversity and ecosystem services and the enhancement of implementation through participation, knowledge management and capacity-building. In Europe and Central Asia an increasing number of countries have become Parties to the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization, which is addressed in Aichi Biodiversity Target 16. By 2014, only eight countries in Europe and Central Asia (15%) were Party to the Protocol, while by 2017, already 25 countries (46%) had joined (CBD, 2017b). Through national biodiversity strategies and action plans (NBSAPs), the Aichi Biodiversity Targets have been translated into national-level targets in all except 13 countries in Europe and Central Asia (<https://www.cbd.int/nbsap/>) (see also Chapter 3), with varying weights assigned to different aspects of the targets (Pisupati & Prip, 2015). Hence, there are good reasons to assume that action will be developed in most of the countries that have completed their post-2010 national biodiversity strategies and action plans and thereby fulfilled one important part of Aichi Biodiversity Target 17. In Western and Eastern Europe, almost all countries have submitted a plan, whereas in Central Asia and Central Europe, a number of countries has not yet submitted (CBD, 2016c). However, the fact that a national biodiversity strategy and action plan has been submitted does not necessarily mean that intended measures, such as the mainstreaming of biodiversity and nature's contributions to people, will be effectively implemented. On the contrary, our assessment of the various policy sectors shows that there are still a number of opportunities to increase the pace of implementation and thereby improve the conservation and sustainable use of biodiversity (see synthesis **Table 6.11**).

In 2015, the 193 member States of the United Nations adopted the 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (Sustainable Development Goals) that were agreed to replace the Millennium Development Goals (United Nations, 2015). Of these, Goal 14 (Conserve and sustainably use the oceans, seas and marine resources) and Goal 15 (Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss) are of particular relevance for nature conservation.

For Europe and Central Asia, the Pan-European Biological and Landscape Diversity Strategy (PEBLDS) was conceived as an instrument to support the implementation of the Convention on Biological Diversity. It was endorsed in 1995 by the Ministers of Environment in the region covered by the United Nations Economic Commission for Europe and thus, reaches well beyond the European Union at the time³⁹. Its aim was to support implementation of the Convention on Biological Diversity and to serve as a coordinating and unifying framework for strengthening and building on existing initiatives (UNEP & UNECE, 2016). In Eastern Europe, the Caucasus and Central Asia, the strategy and related activities were successful in facilitating capacity building for the implementation of the Convention on Biological Diversity and in enhancing NGO involvement. The strategy was terminated in 2011. Prips (2013, p. 5) has drawn a key lesson from this process – *“that policy on its own does not deliver action unless supported by allocation of resources”*. The lack of a financial mechanism with adequate, stable and predictable funding was deemed a major obstacle to the strategy's implementation. Another lesson was that full support from the European Union and its member States was lacking, especially after the enlargement of the European Union. In 2011, a new strategy, the Pan-European 2020 Strategy for Biodiversity (UNEP, 2011b), was developed as the successor to PEBLDS. This new strategy refocuses efforts to prevent further loss of biodiversity in the pan-European region, in line with the Strategic Plan

³⁹ Although the United Nations Environment Programme pan-European region comes close to the area covered by the IPBES Regional Assessment for Europe and Central Asia, it is not quite identical (see UNEP & UNECE, 2016 for an overview of countries belonging to the pan-European region).

for Biodiversity 2011-2020 and its Aichi Biodiversity Targets.

The “EU Biodiversity Strategy to 2020” (European Commission, 2011a, an expansion of the EU Biodiversity Action Plan of 2006) has been instrumental in creating momentum for better integrating aspects of biodiversity and ecosystem services into the European legislation. It works as an umbrella for existing, more specific policies. The strategy consists of six complementary targets whose implementation should contribute to mitigating the main drivers of biodiversity loss in the European Union. The achievement of these targets relies principally on better uptake of existing European Union legislation, notably through a better anchoring of biodiversity objectives in key sectoral policies. Specifically, the six targets focus on: 1) the full implementation of the European Union nature legislation, in particular the Bird and Habitats Directive (improvements of the Natura 2000 network); 2) better protection and restoration of biodiversity and ecosystem services, notably via a greater reliance on green infrastructure development; 3) more sustainable farmland and forestry management, as the agriculture and forestry sectors combined cover almost 72% of the land in the European Union (ameliorations in the common agricultural policy); 4) sustainable management of fish stocks and fisheries (75% of European Union fisheries are overexploited) through a coherent ecosystem approach and reducing bycatch; 5) a tighter control of invasive alien species; and 6) all this in an effort to avert the global biodiversity crisis, notably through a reduction in negative drivers. Each target is accompanied by an ambitious action plan, while indicators for monitoring (since 2010) are provided to ensure the effectiveness of future implementation towards the 2020 biodiversity targets.

Although there has been progress in the implementation of the strategy, it seems unlikely that most of its objectives and targets will be met within the allotted timeframe (EEA, 2015c; European Commission, 2015b; Tittensor et al., 2014; UNEP & CBD, 2016; Chapter 3). In the European Union, the mid-term review of the EU Biodiversity Strategy concluded that, despite progress in most fields and areas, biodiversity loss and ecosystem services degradation continues unabatedly, which casts serious doubts on the “*capacity of biodiversity to meet human needs in the future*” (European Commission, 2015b, p. 4 and 19). The remainder of this section is an assessment of the reasons for this failure, highlighting opportunities for improvements.

6.4.1.2 Governance modes and policy instruments

While top-down, hierarchical governance is still the dominant mode of governance in the conservation sector, international conventions such as the Convention on Biological Diversity, the Aarhus Convention and the 2030 Agenda for Sustainable Development, call for alternative modes of governance to include effective collaboration among different public and private actors and stakeholders to solve environmental problems (see **Figure 6.2**). Greater public engagement through consultation, negotiation, and cooperation in policy design, and in the governance and management of biodiversity, is assumed to be linked with increased effectiveness, sharing of knowledge and understanding and legitimacy of biodiversity conservation and restoration policies (Ansell & Gash, 2008; Bodin & Crona, 2009; Couix & Gonzalo-Turpin, 2015; Decker et al., 2016; Larrosa, Carrasco, & Milner-Gulland, 2016; Paloniemi et al., 2015; Whitehead et al., 2014). As a response to this call, European Union member States and, increasingly, also countries in Eastern Europe and Central Asia (Klůvanková-Oravská, Chobotová, Banaszak, Slavikova, & Trifunovova, 2009; OECD, 2005), tend to highlight the importance of decentralization or public-private governance in conservation policies and strategies. Such governance modes may contribute toward better taking account of the needs of local governments, communities, citizens and local knowledge holders when designing and implementing conservation policies and actions (Yang, Rounsevell, & Haggett, 2015).

New modes of governance have been applied, for example, in the governance of national parks and other protected areas (Holmgren et al., 2016; Kluvánková-Oravská et al., 2009; Reimerson, 2015; Yakusheva, 2017) and in the governance and management of large carnivores and other species. In Western Europe, the legislative and budgetary responsibilities of protected area governance are often vested at subnational levels with important roles for subnational authorities. For example, decentralization processes in France led to closer involvement of local authorities in the management of protected areas, and gave subnational authorities the power to create nature reserves (IUCN France, 2013). This development was further strengthened, giving local authorities a greater role in the governance of national parks, accompanied by changes in intergovernmental fiscal transfers that provided local authorities with more financial resources (Borie et al., 2014). In Central and Eastern European countries, there is a shift from spatially isolated protected areas with top-down regulations towards more connected bottom-up approaches (Kluvánková-Oravská et al., 2009; Yakusheva, 2017). In Central Asia, the institutional mechanisms for biodiversity conservation were developed during the Soviet era and, over the last decades, the management of protected areas has been strengthened, partly due to financial support from international donors. Moreover, protected area coverage has expanded and protection regimes have been widened by introducing categories of protection stipulated by the International Union for Conservation of Nature (IUCN) (Yakusheva, 2017).

With large carnivores recolonizing many European countries (Chapron et al., 2014), mitigation measures to manage human-wildlife conflicts are needed. Norway introduced regional large carnivore committees, with local politicians appointed by the Ministry of the Environment. Sweden has wildlife management delegations at a regional level with politicians and stakeholders, while Finland uses national, regional and local large carnivore management organizations including public and private actors (Redpath et al., 2017; C. Sandström, Pellikka, Ratamäki, & Sande, 2009). These committees are in charge of developing and adopting management plans, determining or providing advice on population targets (including hunting quotas), and mitigating conflicts between wildlife and livestock. They are often also included in monitoring and information sharing (Sjölander-Lindqvist, Johansson, & Sandström, 2015). Human-wildlife conflicts have recently also increased due to the success of the European Union's conservation policies with strictly protected species such as cormorants, otters and the Baltic seal becoming more abundant. This caused the original conflicts with fisheries and aquaculture to resurge so that reconciliation strategies were needed (Klenke, Ring, Kranz, et al., 2013). Such conflicts require relevant stakeholder groups to be brought together, thus moving from hierarchical protection strategies to public-private partnerships, co-management and possibly modes of self-governance. This includes policy instruments such as damage compensation programmes and rewarding land users for biodiversity-friendly practices or monitoring activities as certain human-wildlife conflicts also raise justice concerns in terms of the distribution of their damages (Jacobsen & Linnell, 2016; see also Box 2.5). As the core of the conflict usually consists of different interests and values among different stakeholder groups, successful conflict reconciliation strategies take stakeholder perceptions seriously and build on participatory processes (Klenke, Ring, Máñez Schwerdtner, et al., 2013; Manfredo, Vaske, Brown, Decker, & Duke, 2009). Further empowerment of national and local stakeholders is also considered key to success in wildlife management in Central Asia. Successful conservation measures require multi-stakeholder partnership and integrated efforts, yet regional cooperation in Central Asia still faces a number of challenges (Michel, Yakusheva, Pesch, & Baldus, 2015). These include the economic situation, with continuous financing depending on external donors, and differing cultural perceptions and values with regard to wildlife and hunting.

Although the arguments in favour of these new modes of governance and the studies supporting these claims are many, there is also evidence that participation does not always deliver substantial benefits. Hence, caution is warranted against considering these new modes of governance as solutions for all

31013 kinds of conservation challenges. For example, there are problems related to the representation of
 31014 different interests, the lack of opportunities for deliberation, the lack of mechanisms for conflict
 31015 resolution, and misunderstandings of the mechanism by which decisions are made (Ansell & Gash,
 31016 2008). Nevertheless, in spite of these problems, studies also show the potential of participatory
 31017 processes to contribute to social and organizational learning, as well as to the achievement of
 31018 conservation and management outcomes (Emerson & Nabatchi, 2015).

31019 **The toolbox of policy instruments** for biodiversity conservation, ecosystem restoration and sustaining
 31020 nature's contributions to people, is well equipped. Due to the many challenges and complexities, real-
 31021 world policies for the conservation, restoration and sustainable use of biodiversity typically apply
 31022 multiple instruments at the same time. These challenges involve dealing with heterogeneity and
 31023 multiple objectives, irreversibility in the face of species extinction and tipping points in ecosystems,
 31024 information gaps, diverse values, multiple market, policy and institutional failures, a wide range of
 31025 drivers impacting nature, and multiple actors at different spatial scales (OECD, 1999; Ring & Schröter-
 31026 Schlaack, 2011, 2015; TEEB, 2011b). A comprehensive literature review of the various instruments for
 31027 biodiversity conservation and the sustained provision of ecosystem services showed that combinations
 31028 of instruments can be justified for a range of motives. Based on this review, **Table 6.5** presents
 31029 characteristics of the major instruments reviewed as well as the main findings for the performance of
 31030 the different instruments (Ring & Schröter-Schlaack, 2011, 2015; Schröter-Schlaack & Ring, 2011). Each
 31031 instrument category covered (legal and regulatory, economic and financial, social and information-
 31032 based instruments) has a role to play in an overall policy mix due to varying goals, actors addressed,
 31033 and policy context.

31034 **Legal and regulatory instruments** are the backbone of policy mixes, necessary to promote the
 31035 conservation, restoration and sustainable use of biodiversity. Establishment of protected areas and
 31036 their networks is an essential policy response to habitat loss and fragmentation (see Chapter 4, Section
 31037 4.5) (Secretariat of the CBD, 2014; UNEP & UNECE, 2016). This legal instrument is implemented in all
 31038 subregions of Europe and Central Asia, although with room for improvement (see corresponding
 31039 column in synthesis **Table 6.11**). The core of the European Union biodiversity policy is the Habitats
 31040 Directive and the Birds Directive, which established the Natura 2000 network. Member States have to
 31041 implement the Nature Directives through national conservation law. Although not obligatory, the
 31042 European Commission strongly recommends management plans as an operational instrument
 31043 outlining practical measures to achieve the conservation objectives for Natura 2000 sites (EEA, 2015c).
 31044 Whether part of management plans or not, member States are required to draw up conservation
 31045 measures applying to all habitats and species on the Natura 2000 sites. A recent analysis of national
 31046 reports by the European Environment Agency (EEA, 2015c) showed that conservation measures
 31047 related to spatial planning (e.g. establishing protected areas or sites, legal protection of habitats and
 31048 species, and other spatial measures) dominate the commonly reported conservation measures.
 31049 Further significant categories include measures related to wetland, freshwater and coastal habitats,
 31050 agriculture and open habitats and forest habitats. As the terrestrial part of the Natura 2000 network
 31051 is predominantly covered by woodland, cropland and grassland, mainstreaming biodiversity into
 31052 agriculture and forestry is a key task (Sections 6.5.1 and 6.5.2).

Table 6.5: Reviewing the performance of selected single instruments for biodiversity conservation

Instrument type	Direct regulation, e.g. protected area designation	Offsets, habitat banking and permit trading	Tax reliefs	Ecological fiscal transfers	Payments for ecosystem services (PES)	Certification, e.g. forest certification
Goal	Safeguard important areas for species and habitat conservation	Account for and mitigate inevitable impacts on biodiversity and ecosystems	Account for positive environmental externalities provided by land users	Compensating decentralized governments for opportunity and/or management costs as well as spillover benefits of protected areas	Incentivizing land users for biodiversity conservation and ecosystem service provision, e.g. by compensating for associated opportunity and management costs	Promote biodiversity- and environmental-friendly forest production in accordance with legal codes and certification requirements
Actors addressed	Private and public actors	Private and public actors	Private actors	Public actors	Mostly private actors/land users	Private actors (consumers)
Baseline and policy context	Protection provided by other primary instruments (e.g. emission / management standards) or existing protected area network, very often no protection at all	Impacts allowed by (management / emission / performance) standards	Tax payers' behaviour without the tax relief (business as usual might be biodiversity friendly anyhow)	Protected areas coverage when instrument is introduced	Land-use practice without incentives by payment for ecosystem services schemes (business as usual could be either static, declining or improving)	National forestry regulation, certification process most often progressive and adaptive
Conservation effectiveness	High – increase in and conservation of biodiversity and ecosystem service provision; however, effectiveness may be at risk due to weak enforcement or may erode in the future due to changing environmental conditions (e.g. climate change)	Medium – although typically designed to allow for a “no net loss”-goal, problems arise in assuring equivalence of mitigation measures and their long-term monitoring	Low – depending on tax burden relieved (existence of tax, actual enforcement of payments, and sufficient tax rate); non-targeted approach	Medium to high – increase in quantity and quality of protected areas likely (especially when beneficiary of transfers can influence quantity and quality of protected areas)	Low to high – depending on instrument design regarding baseline, and additionality, leakage, permanence and participation	Medium – impacts dependent on rigorosness of standard and framing conditions, such as intensity of investment, difficulties in transport and licensing, land tenure and conflicts with competing land uses
Associated costs and proxies for cost-effectiveness	Medium – though protected areas very often show a positive benefit-cost-relationship, local opportunity costs can be substantial	High – in particular the option to trade mitigation measures significantly reduces opportunity costs; however, some ecosystem or habitat types may be (too) costly to restore	Medium – low transaction costs as resting on existing administrative procedure; however, very often incentives provided insufficient for required change in land-use practice	Medium – low transaction costs as it builds on existing mechanism (fiscal transfer schemes and protected areas designation)	Medium to high – no up-front public investment for buying land, auction-based programmes limit excessive rents; however potentially high transaction costs	Medium – administrative costs of certification scheme may be substantial (in particular in tropical forests)
Social impacts and equity	Medium – ecosystem services protected by protected areas may benefit (local) population; however, substantial opportunity costs and risk to revoke informal rights (e.g. access/abstraction) in area designation	Medium – increase in education/job and income opportunities for rural landowners marketing offsets; compensation of opportunity cost of land conservation (tradable development rights)	Medium – compensation for opportunity costs of environmentally friendly land-use practices; however, only applicable to tax debtors (e.g. landowners)	Medium – depending on entry point of protected areas in fiscal transfer systems; fiscal transfers as such address inequalities between jurisdictions	Medium – support of rural livelihoods, resource management and social coordination capacities; but enrolment constrained by insecure property rights and transaction costs, mixed effect on poverty alleviation	Low to medium – difficult to reach smaller operators due to complex procedures; communities often benefit through workforce participation and engagement in co-benefits

Source: Adapted from (Ring & Schröter-Schlaack, 2015; Schröter-Schlaack & Ring, 2011), based on individual instrument reviews from (Kaechele, May, Primmer, & Ludwig, 2011; Oosterhuis, 2011; Porras, Chacón-Cascante, Robalino, & Oosterhuis, 2011; Ring et al., 2011; Ring, Droste, & Santos, 2017; R. Santos, Schröter-Schlaack, et al., 2015; Schröter-Schlaack & Blumentrath, 2011).

Many of the recent improvements in biodiversity conservation have been a result of effective regulation. The European Union Nature Directives allows the European Union to meet its objectives under international law, and, by way of the Natura 2000 network, have led to an increase in the number and quality of protected areas (UK NEA, 2011, p. 53). The Natura 2000 network is now the most extensive network of protected areas in the world, including more than 27,000 sites and covering 18% of the terrestrial area of the European Union member States and 4% of European Union marine waters (EEA, 2015c). The marine component of the Natura 2000 network is still very incomplete, particularly for offshore sites, yet with substantial designations in recent years (EEA, 2012a, 2015c). The Natura 2000 network forms the backbone of the European Union's green infrastructure (Mazza et al., 2011). The Emerald Network launched by the Council of Europe in 1999 is based on the same principles as Natura 2000 and represents its extension to non-European Union countries (EEA, 2012a; UNEP & UNECE, 2016). The Pan-European Ecological Network, originally launched in the framework of the Pan-European Biological and Landscape Diversity Strategy, builds on the Natura 2000 network and the Emerald network. In addition to the latter two, the Pan-European Ecological Network aims at linking core areas physically by way of preserving and restoring corridors (Jongman, Bouwma, Griffioen, Jones-Walters, & Van Doorn, 2011; UNEP & UNECE, 2016). Protected areas as a legal conservation policy instrument are widely applied in Eastern Europe and Central Asia, although problems exist with enforcing regulations and effective monitoring due to insufficient institutional capacities and human and financial resources (Mammadov et al., 2016; OECD, 2005).

Economic and financial instruments in conservation policies penalize activities that negatively affect the environment, or they provide public and private actors with the resources needed to achieve conservation goals and to implement conservation measures. Biodiversity financing by way of public financial support programmes is an important topic in Europe and Central Asia. Apart from a few dedicated biodiversity conservation funding schemes such as the LIFE fund, the European Union's approach to financing biodiversity and nature conservation is largely based on "integrated financing", using a range of existing financial instruments from other sectors, such as agriculture, fisheries and regional development, as well as social and cohesion funds (Kettunen et al., 2017). Since financial resources still fall far short of providing sufficient resources to achieve agreed biodiversity objectives (Gantioler et al., 2010; Tucker, Underwood, et al., 2013), Kettunen et al. (2017) suggest a range of policy instruments as opportunities for innovative biodiversity financing in the European Union, among them ecological fiscal transfers (EFT), tax reliefs, marketed products as well as fees and charges (Kettunen & Illes, 2017). (Ring & Barton, 2015; Ring & Schröter-Schlaack, 2011) provide a review of economic instruments in policy mixes for biodiversity conservation and the sustained provision of ecosystem services, assessing their effectiveness, associated costs and social impacts, and pointing to shortcomings and misperceptions of the relevant instruments (**Table 6.5**). Whereas payments for ecosystem services are commonly implemented in Western and Central Europe (although with scope for improvement, see synthesis **Table 6.11**), further economic instruments are only applied in a few countries, are under development or have only recently started. Portugal was the first European Union member State to introduce ecological fiscal transfers, using Natura 2000 sites and other national protected areas as indicators for redistributing general tax revenues from the national level to all municipalities hosting such areas (R. Santos, Ring, Antunes, & Clemente, 2010). In this way, economic instruments can support the implementation of legal and regulatory instruments by providing financial resources to subnational governments responsible for managing such sites.

There is room for considerable development of economic instruments in nature conservation and ecosystem restoration policies especially in Eastern Europe and Central Asia, where few countries apply such instruments (Kobakhidze, 2015; OECD, 2005; UNEP & UNECE, 2016). The current work programme of the Pan-European Biodiversity Platform includes as one of its three overarching priorities, "improving the manner in which biodiversity and ecosystem services concerns and

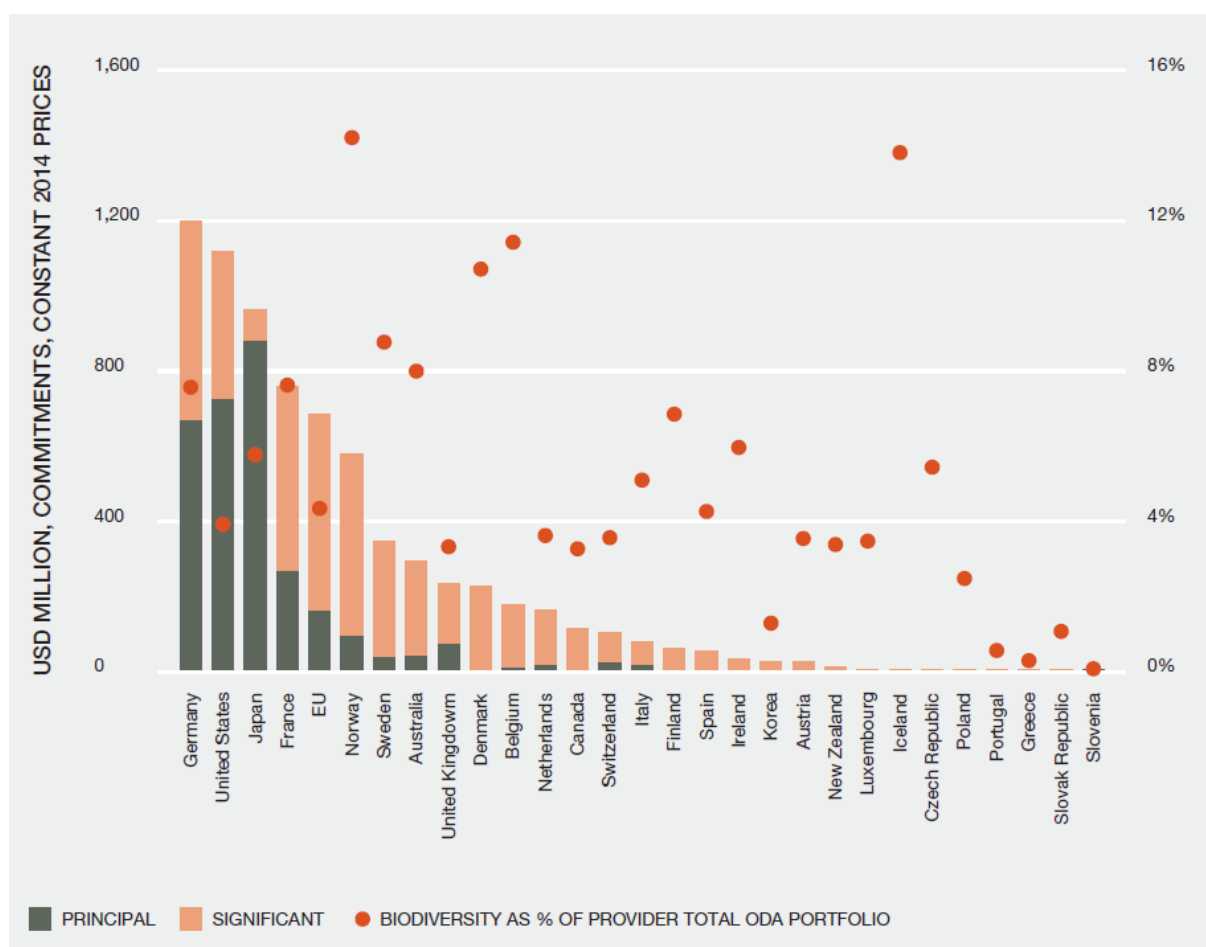
31104 *requirements are reflected in economic and development frameworks and policies”* (UNEP, 2014b, p.
 31105 7). Selected activities supported under this priority include: (i) mapping and assessing ecosystems and
 31106 their services; (ii) in-country and subregional studies following the approach of the international
 31107 initiative on the economics of ecosystems and biodiversity (TEEB); and (iii) capacity support for the use
 31108 of market-based instruments (UNEP, 2014b). Especially following the publications of the TEEB
 31109 initiative, market-based instruments have been gaining ground in policy strategies for conservation.
 31110 In Eastern Europe and Central Asia, for example, payments for environmental services have been
 31111 introduced and tested as pilot projects in some countries. However, these initiatives are supported by
 31112 donors and their national ownership is low. There is no observed trend of wider application of this
 31113 instrument in the region.

31114 **Social and information-based instruments** operate by providing additional information for policy
 31115 target groups on the impacts of their activities regarding biodiversity and nature’s contributions to
 31116 people. Certification acts as a bridge between market regulation and conservation governance by
 31117 emphasizing specific criteria in response to consumers’ demands for sustainably produced products
 31118 (see Sections 6.5, 6.6.2 and 6.6.5.3 for applications in agriculture, forestry and fisheries and the role of
 31119 certification as part of a policy mix; synthesis **Table 6.11**). Regarding science, data, indicators and
 31120 monitoring, the Environmental Performance Reviews of the United Nations Economic Commission for
 31121 Europe provide regular knowledge updates on a number of biodiversity-relevant issues, covering
 31122 countries in Central Europe, Eastern Europe (except Russian Federation) and Central Asia (see UNECE,
 31123 2017b for reviewed countries, 2017c; UNEP & UNECE, 2016).

31124 **Rights-based instruments and customary norms** are especially important for indigenous and local
 31125 people. Over recent decades, the rights of indigenous peoples have been increasingly acknowledged
 31126 and strengthened within the international legal system (Section 6.3.2.6). To some extent, this is also
 31127 reflected in national-level biodiversity conservation policies in Europe and Central Asia. One example
 31128 of this policy change is the management arrangement for the Laponia World Heritage site in northern
 31129 Sweden where the Sami have secured significant influence over the management of the site, and label
 31130 it a victory for Sami political struggle (Reimerson, 2015). There are also many marine areas where the
 31131 customary laws of indigenous peoples are recognized and respected by the broader society (EEA,
 31132 2012a). Indigenous and local knowledge is a rich source of local understandings and traditional
 31133 management practices that can play an important role in the conservation and sustainable use of
 31134 biodiversity (Babai et al., 2015; Hartel, Plieninger, & Varga, 2015; Zsolt Molnár, 2014; Oteros-Rozas et
 31135 al., 2013; Roué & Molnár, 2017; Varga et al., 2016; Varga & Molnár, 2014). Examples of such traditional
 31136 management practices and extensive measures are livestock grazing in lowland grasslands; mowing by
 31137 hand in montane grasslands, and; coppicing, pollarding or small-scale felling in forests. Local foresters,
 31138 herders and rangers may recognize and provide explanations to structural and species compositional
 31139 changes in different ecosystems and their knowledge is often passed on over many generations
 31140 (Berkes et al., 2000).

31141 **The mobilization of financial resources** is a continuous task, to which Aichi Biodiversity Target 20 is
 31142 dedicated. Sufficient financial resources are considered crucial if biodiversity is to be conserved and
 31143 the sustainable use of biodiversity and ecosystems enhanced. This holds especially true for developing
 31144 countries with limited domestic funds (Richerzhagen, Rodríguez, & Stepping, 2016). In Europe and
 31145 Central Asia, Turkey and the Ukraine were among the top 10 recipients globally of bilateral
 31146 biodiversity-related official development assistance, whereas 20 Western European and 3 Eastern
 31147 European countries as well as the European Union were providers of such assistance (**Figure 6.4**). The
 31148 top 10 providers account for nearly 90% of biodiversity-related official development assistance, among
 31149 them six European countries and the European Union (all figures 2011-2015 average) (OECD, 2016a).
 31150 **Figure 6.5** shows the global distribution of biodiversity-focused aid from Development Assistance

31151 Committee members of the OECD for the years 2006 – 2012, with only few recipients in Europe and
 31152 Central Asia.



31153
 31154 **Figure 6.4: Providers of bilateral biodiversity-related official development assistance (ODA), among**
 31155 **them 23 countries from Western and Central Europe and the European Union (EU). This figure**
 31156 **considers only members of the Development Assistance Committee of the OECD. “Principal” means**
 31157 **that biodiversity was targeted as a primary objective, implying that activities would not have been**
 31158 **funded but for their biodiversity-related goals. “Significant” means that biodiversity was targeted as**
 31159 **a secondary objective, indicating that biodiversity is being mainstreamed into development**
 31160 **cooperation activities with other primary objectives. Norway, Iceland and Belgium dedicated the**
 31161 **highest shares of their official development assistance portfolios to biodiversity-related activities**
 31162 **(see red dots relating to right-hand y-axis). Source: (OECD, 2016a).**

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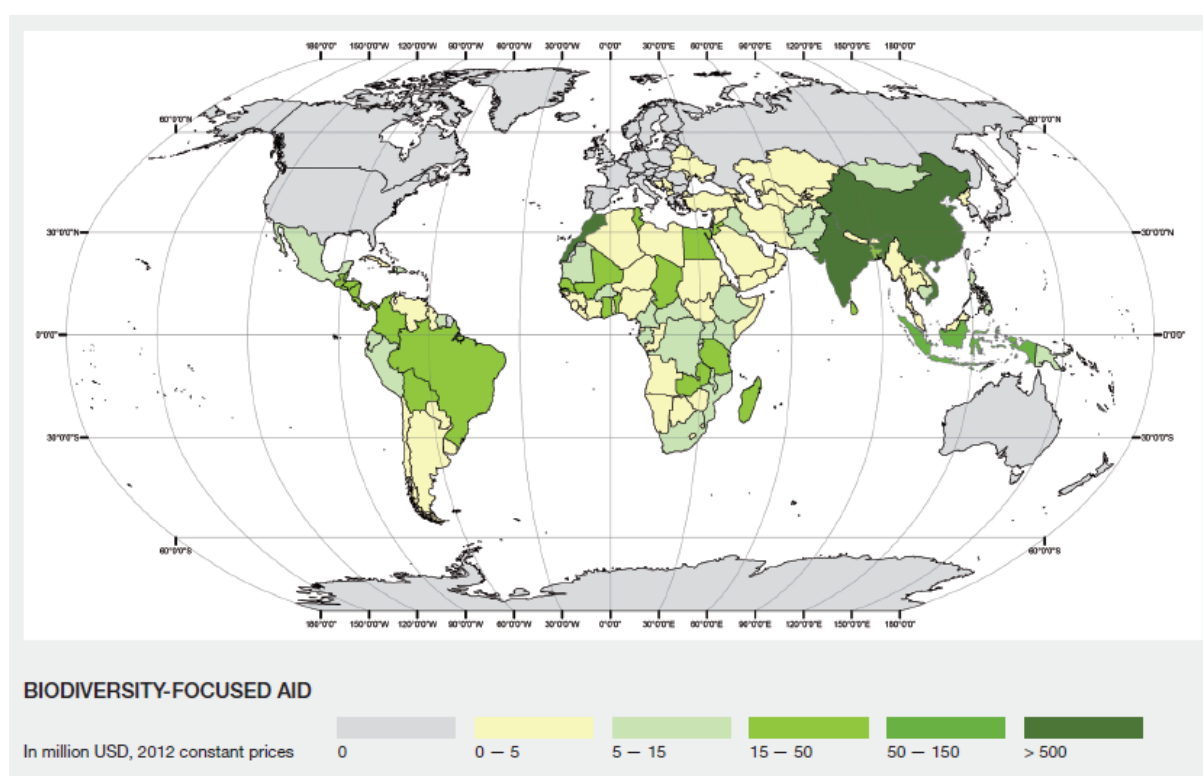


Figure 6.5: Biodiversity-focused aid from Development Assistance Committee members of the Organisation for Economic Co-operation and Development. Source: adapted from (UNEP-WCMC & Secretariat of the Biodiversity Indicator Partnership, 2017); Data: (OECD, 2017).

6.4.1.3 Constraints and opportunities

Despite accelerating policy and management responses to the global loss of biodiversity, the impacts of these efforts are unlikely to be reflected in improved trends in the state of biodiversity by 2020 (Tittensor et al., 2014). In view of these developments, (Di Marco, Watson, Venter, & Possingham, 2016) call for a refocus of biodiversity conservation priorities, by defining sufficient and more ambitious biodiversity targets, increasing the amount of financial resources necessary to achieve these targets, and spending them more efficiently. Recent reviews and assessments at the regional level mirror these findings and necessities stated for the global level, including for Europe and Central Asia. The mid-term review of the EU Biodiversity Strategy to 2020 (European Commission, 2015b) emphasizes that key threats to biodiversity continue to exert pressure. Land-use change, in particular through urban sprawl, agricultural intensification, land abandonment and intensively managed forests, pollution, extraction of natural resources (e.g. mining, fisheries), invasive species and climate change, still cause loss of species and habitats and result in ecosystem degradation and weakening of ecosystem resilience (Chapter 4) (EEA, 2015d; European Commission, 2015b; UNEP & UNECE, 2016).

The failure of the European Union's 2010 target to halt biodiversity loss has been attributed to the following major problems (Fournier, Gantioler, Good, Herkenrath, & Mees, 2010; Tinch, Schoumacher, & van den Hove, 2011): "(a) incomplete implementation of existing legislation; (b) insufficient funding; (c) limited awareness about biodiversity; (d) inadequate governance and administrative capacity; and (e) gaps in skills and knowledge." Despite the adoption of the EU Biodiversity Strategy 2011 – 2020, it has been argued that these problems still apply (Tucker, Allen, et al., 2013). In a similar vein, Steiner (2009) (cited in Tinch et al., 2011), stated from a global perspective that current governance systems cannot achieve environment and development goals "due to lack of adequate financing, incoherence

among bodies, weak linkages between science and policy, insufficient capacity at the national level to implement laws and policies, and a significant disconnect between the environmental and the economic and social spheres.” Therefore, short-term priorities tend to dominate long-term visions, and societies fail to consider and develop transformative strategies for achieving sustainability. Recognition of the need for profound societal transformation towards sustainability has just started. It is gaining momentum in Western Europe (EEA, 2015d), but still needs to be initiated in other subregions of Europe and Central Asia (see synthesis **Table 6.11**). All policy options and opportunities related to awareness raising in the synthesis **Table 6.11**, would need stronger support in Eastern Europe and Central Asia to become effective.

Mainstreaming biodiversity and nature’s contributions to people into all policy areas that depend on or affect biodiversity, has become a key strategy to counteract these deficiencies. In Europe and Central Asia, as well as globally, the concept of a “green economy” is gaining increasing support (Economic Commission for Europe, 2016; European Commission, 2013b; UNEP, 2011a, 2016a). Biodiversity conservation, sustainable resource use and ecosystem restoration feature prominently on the agenda of these strategies. However, despite the long recognition of the need for mainstreaming, there remain important barriers such as “shortcomings in training and a lack of skills, guidance and tools to enable non-specialists from other sectors to take account of both their dependence and their impacts on biodiversity and ecosystems” (Tinch et al. 2010). Promoting information sharing, transparency, knowledge management and training is of special relevance in Eastern Europe and Central Asia (see synthesis **Table 6.11**).

The heterogeneity of biodiversity conservation, with its multiple taxa, organizational levels and multiple objectives, represents a key challenge for policy development. Biodiversity also affects many aspects of society, different sectors, and is highly relevant in spiritual, religious and cultural contexts. In response to these complex challenges, a huge number of international and regional conventions and policy instruments deal with biodiversity in Europe and Central Asia. For many countries in the region, it has become increasingly difficult to fully implement or even follow the targets set by the Strategic Plan for Biodiversity 2011-2020, due to its vast range of topics and issues (UNEP & UNECE, 2016). Institutional fragmentation between different policy sectors represents another barrier to achieving biodiversity objectives. It involves split competences, conflicts, and scale and boundary mismatches between regulatory authorities and biodiversity processes (Koetz, Farrell, & Bridgewater, 2012). Such fragmentation can lead to policies harmful to biodiversity. Examples are found in policy sectors such as energy, transport, fisheries or agriculture (see Sections 6.5.1, 6.5.3, 6.5.4 and 6.5.5). Phasing out of harmful subsidies remains an important task for all policy sectors and across all subregions of Europe and Central Asia (synthesis **Table 6.11**). Conversely, more progress has been made in relation to taxing and charging negative environmental impacts, with the exception of the fisheries sector (see Section 6.5.3 and synthesis **Table 6.11**) (Hansjürgens, Schröter-Schlaack, et al., 2011; M. Lehmann et al., 2011; OECD, 2013b).

Mainstreaming and policy integration remain a priority. This includes setting and achieving objectives in policy areas not directly targeted by biodiversity policies, notably other environmental policies such as climate, air, chemicals, water and soil protection (see next Section 6.4.2) and further sector policies such as agriculture, forestry, fisheries, resource extraction and manufacturing, and the services sector (see Section 6.5) (EEA, 2015c; European Commission, 2015b; PBL, 2014; Tinch et al., 2011; UNEP & UNECE, 2016). Beyond certain thresholds or “tipping points”, impacts may be irreversible and cause species extinction or ecosystem collapse. Small impacts accumulating over a long period may create large losses with irreversible outcomes. Making trade-offs and tipping points visible at the relevant spatial scales remains an important policy option for all subregions of Europe and Central Asia (synthesis **Table 6.11**). If early warnings are taken seriously and preventative action is taken, negative

outcomes can be avoided or at least reduced. Precautionary approaches can help manage the fast-changing, multiple, systemic challenges the world faces today (EEA, 2013b).

Recent progress in establishing policy frameworks needs to be translated into concrete actions at national, subnational and local levels, if the status of biodiversity is to improve on the ground. Full exploitation of current commitments is needed, as well as stepping up efforts to improve on the current situation in critical policy areas such as biodiversity (UNEP & UNECE, 2016). Improved science-policy interfaces such as IPBES, and relevant interfaces and networks at subregional, national and subnational levels, currently serve as valuable mechanisms to provide the best available evidence for evidence-based policymaking. A key opportunity is to demonstrate to business the benefits it derives from biodiversity, and the ways in which it can manage its impacts on biodiversity (see Aichi Biodiversity Target 4) (TEEB, 2012) (See also Sections 6.5.4, 6.5.5 and 6.6.3.2). Due to the multifaceted relationships and interlinkages between so many policy sectors and societal actors, the concept of nature's contributions to people provides opportunities to better assess synergies and trade-offs between biodiversity conservation and the many contributions of nature to people and quality of life (Bouma & Beukering, 2015; Elmqvist et al., 2010; Potschin, Haines-Young, Fish, & Turner, 2016; for ecological restoration: Tolvanen & Aronson, 2016) (**Box 6.1**).

Box 6.1: Synergies and trade-offs: assessing the links between biodiversity and nature's contributions to people

Although the number of publications on ecosystem services has increased markedly in recent years (see Chapter 1 and Chapter 2), we still have limited understanding of the synergies and trade-offs between biodiversity and nature's contributions to people, or ecosystem services (Elmqvist et al., 2010; Turkelboom, Thoonen, Jacobs, & Berry, 2016). Trade-offs exist between material contributions to people, (or provisioning services) and biodiversity, but also between biodiversity and other categories of ecosystem services, as the Millennium Ecosystem Assessment (MA, 2005c) has prominently stated. Intensification in the provision of material contributions may arise from objectives in other policy sectors, e.g. climate and related agricultural, forestry or energy policies (see Sections 6.4.2, 6.5.1, 6.5.2 and 6.5.4).

For example, policies for climate change mitigation involve moving from fossil fuels to renewable energy sources, often accompanied by financial incentives to land users in agriculture or forestry that lead to intensified production. Albert and co-authors, for example, assessed biodiversity and ecosystem service trade-offs in agrarian landscapes that arise from increased biogas production in Germany (Albert, Hermes, Neuendorf, von Haaren, & Rode, 2016). Policies promoting forest expansion for increased carbon sequestration at the expense of semi-natural grasslands may further risk the overall reduction of biodiversity in the European Union (Burrascano et al., 2016). In Eastern Europe and Central Asia, many low-income rural households still rely on traditional biomass (straw, wood or coal) for cooking and heating. Here, the development of proper management systems promises to prevent the loss of biodiversity and degradation of local biomass resources (IEA, 2015; Kobakhidze, 2015).

Mainstreaming biodiversity into climate change mitigation and adaptation policies also has the potential for various synergies. This is the case for peatland conservation and re-wetting of farmed peatlands, sustainable forest management or the conservation and restoration of near-natural floodplains (Natural Capital Germany - TEEB-DE, 2015). Further synergies relate to the significant overlap between Natura 2000 sites and regions with high carbon content across European Union countries. Biodiversity protection and climate change mitigation through conservation of soil carbon could be simultaneously achieved in Natura 2000 sites and beyond (Jantke, Müller, Trapp, & Blanz, 2016). Considering bundles of ecosystem services and the multifunctionality of landscapes helps to tease out such synergies (Howe, Suich, Vira, & Mace, 2014; Mouchet et al., 2017; Ruijs, Wossink, Kortelainen, Alkemade, & Schulp, 2013; Sil et al., 2016).

At a more general level, mapping and assessments of nature's contributions to people provide valuable information for a range of public and private decision-makers (Chapter 2). The provision of biophysical maps of ecosystem services at the European Union level is regarded as a crucial step in setting new targets for biodiversity (Rodwell, Janssen, Gubbay, & Schaminee, 2013). (Maes et al., 2014, 2015, 2016; Schröter et al., 2016) have taken

31288 important steps towards mapping and assessing ecosystem services in the European Union. Comparable
 31289 initiatives exist for Eastern Europe (Bukvareva et al., 2015; Grunewald, Bastian, & Drozdov, 2014). In Central Asia,
 31290 most recent ecosystem (service) assessments have been performed in relation to sustainable land management
 31291 by the Economics of Land Degradation (ELD) initiative (Quillérou et al., 2016).

31292 **End of Box 6.1**

31293

31294 It is expected that the shift from traditional hierarchical modes of governance towards more inclusive
 31295 modes such as public-private partnerships or co-governance would result in better decisions and policy
 31296 outcomes. This holds for the literature assessed, as well as international conventions and national
 31297 policies. The inclusion of stakeholders and/or previously marginalized actors in consensus-based,
 31298 deliberative processes in policymaking and decision-making is seen as a promising mechanism for
 31299 managing environmental problems including conservation. This would enhance the effectiveness,
 31300 efficiency and equity of the decision-making process, by reducing transaction costs, improving the
 31301 legitimacy of decisions, and increasing the sustainability of resources and livelihoods (Bodin, 2017).
 31302 While there is a growing literature on these more inclusive modes of governance in relation to wider
 31303 environmental issues, agriculture, forestry and fisheries (see Sections 6.4.2 and 6.5), there is no
 31304 comprehensive overview on the role of participation in setting priorities for biodiversity policies.
 31305 Furthermore, the focus in the literature is often on the processes of inclusion and not on the outcomes
 31306 in terms of overall effectiveness of biodiversity policy. Although some countries in Europe and Central
 31307 Asia, for example, produced second-generation national biodiversity strategies and action plans in the
 31308 early 2000s through participatory processes (Moreno & Mueller, 2015; UNEP & CBD, 2016), there
 31309 remains a considerable gap in addressing issues of public involvement, in particular concerning gender
 31310 equality and women's empowerment, as well as the participation of indigenous peoples. Indigenous
 31311 and local knowledge of biodiversity and nature's contributions to people in conservation policy and
 31312 management is not sufficiently taken into consideration despite the recognition of the importance of,
 31313 for instance, traditional farming (European Commission, 2014a; Roué & Molnár, 2017). Furthermore,
 31314 linkages between science and policy, and between science and society, can be strengthened in this
 31315 context (Arlettaz et al., 2010; Buizer, Arts, & Kok, 2011; Mihók et al., 2015; Pullin et al., 2009). By taking
 31316 individual and social preferences of people seriously, economics, the wider social sciences, and the
 31317 humanities, may help to facilitate conservation policies, actions and outcomes that are more
 31318 legitimate, salient, robust and effective compared to the current situation (Bennett et al., 2017; Moon
 31319 & Blackman, 2014). This has proven to be fruitful in relation to human-wildlife conflicts, where human
 31320 dimensions of wildlife have developed as a transdisciplinary research field (Manfredo et al., 2009;
 31321 Paxton et al., 2016). The same holds for nature's contributions to people, which have been developed
 31322 as a boundary concept between the natural and the social sciences (Bouma & Beukering, 2015;
 31323 Potschin et al., 2016).

31324 Although budgets for financing biodiversity conservation activities have been increased in recent
 31325 years, adequate financing of biodiversity conservation is still lacking at the national level and
 31326 throughout Europe and Central Asia (Florentina, Maria, Adrian, & Simona, 2015; Kettunen et al., 2017;
 31327 Mammadov et al., 2016; Tucker, Underwood, et al., 2013). The interim assessment of revised national
 31328 biodiversity strategies and action plans found that many strategies and action plans were overly
 31329 ambitious, while at the same time lacking a strategy for financing their implementation (Pisupati &
 31330 Prip, 2015). The situation is especially serious in Central and Eastern Europe as well as in Central Asia,
 31331 where insufficient capacity has been identified at the national level to implement laws and policies as
 31332 well as to better deploy participatory approaches (Mammadov et al., 2016; Mihók et al., 2017;
 31333 Niedziałkowski, Pietrzyk-Kaszyńska, Pietruczuk, & Grodzińska-Jurczak, 2015; Simeonova, Simeonova,
 31334 & Van Der Valk, 2016). The financial resources for scientific research, monitoring and training of

31335 specialists in the field of biodiversity conservation are deemed seriously insufficient in Eastern Europe
31336 and Central Asia (Kobakhidze, 2015).

31337 However, lack of resources for biodiversity financing also applies to European Union member States.
31338 The mid-term review of the EU Biodiversity Strategy stated that achieving biodiversity targets requires
31339 adequate funding, yet there is still no detailed insight into the actual funding and financing of nature
31340 conservation by each member state. The review, supported by more recent assessments, calls for
31341 expanding the multi-fund approach to biodiversity financing, better linking the various existing
31342 financing tools, and exploring new economic and financial policy instruments that can provide funds
31343 for achieving objectives related to biodiversity and nature's contributions to people (European
31344 Commission, 2015b, 2016b; Kettunen et al., 2017). For example, countries such as India and Brazil use
31345 conservation-related indicators for redistributing general tax income much more prominently than any
31346 country in Europe or Central Asia (Busch & Mukherjee, 2017; Ring, 2008b; Schröter-Schlaack et al.,
31347 2014). Redistributing public revenues through intergovernmental fiscal relations from higher to lower
31348 levels of government may account for the opportunity costs of conservation, reward conservation
31349 activities of municipalities, and thus can provide incentives for conservation, when considering
31350 ecological and conservation-related indicators in redistribution formulas (Droste, Lima, May, & Ring,
31351 2017). Such approaches also have the potential to be transferred to the distribution of European Union
31352 funds between the European Union and member States (Droste, Ring, Santos, & Kettunen, 2016;
31353 Kettunen et al., 2017), or, more generally, for redistributing international funds, for example in relation
31354 to REDD+ initiative (Ring, Drechsler, van Teeffelen, Irawan, & Venter, 2010).

31355

31356 6.4.1.4 Summary

31357 There is a widespread call to strengthen the synergies between biodiversity-related conventions, to
31358 improve policy integration and mainstream biodiversity and nature's contributions to people into
31359 relevant policy sectors, as the complexity and fragmentation of biodiversity governance is seen as a
31360 constraint to effective policy design and implementation. IPBES may play an important role in the
31361 integration of relevant political processes and instruments (UNEP & UNECE, 2016, p. 89). Current
31362 assessments of status and trends of biodiversity and nature's contributions to people as well as policy
31363 responses indicate the need to strengthen the implementation of existing policies (EEA, 2015d;
31364 Tittensor et al., 2014; UNEP & UNECE, 2016) (see Chapters 2–5). This requires full exploitation of
31365 current commitments to reach agreed environmental goals and targets and proactive learning from
31366 the wide spectrum of good-practice in the region. In critical areas, such as biodiversity, additional
31367 commitments and efforts are needed to improve on the current situation, including sufficient
31368 mobilization of financial resources (UNEP & UNECE, 2016).

31369 Legal and regulatory instruments are the backbone of policy mixes for biodiversity conservation. Direct
31370 regulation, including, for example, protected areas, land-use management standards, or zoning
31371 regulations by spatial planning, is the most widely used approach in environmental protection, and
31372 this also holds true for biodiversity conservation (Schröter-Schlaack & Blumentrath, 2011). A well-
31373 defined and comprehensive regulatory framework provides the essential baseline for introducing
31374 other instruments (Hansjürgens, Schröter-Schlaack, et al., 2011). It can help to assure a safe minimum
31375 standard of conservation, making it an important ingredient in any conservation strategy. However, its
31376 social and equity impacts are somewhat mixed (Schröter-Schlaack & Ring, 2011), especially in relation
31377 to indigenous and local people (Allard, 2006; Elenius, Allard, & Sandström, 2017). On the one hand,
31378 regulation makes use or access rights legally enforceable due to clearly defined property rights. This is
31379 an important enabling condition for the use of market-based instruments in conservation policies to
31380 work effectively. On the other hand, there is the risk of precluding informal property rights, such as

those of indigenous peoples. For Kyrgyzstan, Kalkanbekov and Samakov (2017) suggest sacred sites to be considered as indigenous protected areas or, in other words, community-conserved areas, to increase their recognition as valuable nature-related cultural sites.

Applying and improving a wider range of economic instruments in the conservation and sustainable use of biodiversity and natural resources, as well as ecosystem restoration policies, remains a task in all subregions. It is important to note, however, that economic instruments include more options than only “market-based” instruments. The latter term is widely used by many stakeholders, often confusing everything related to economics, with markets (Vatn, 2015; Vatn et al., 2011). Economic instruments in general require: (i) creation of the enabling conditions through legal and regulatory instruments; (ii) smart design and effective implementation; and (iii) consideration of their social impacts on the ground (W. M. Adams, Hodge, Macgregor, & Sandbrook, 2016; Kettunen & Illes, 2017; Ring & Schröter-Schlaack, 2011; R. Santos, Schröter-Schlaack, et al., 2015; Tinch et al., 2011).

Social and information-based instruments are essential in the wider policy mix for biodiversity conservation. Although regular reporting and monitoring on the state of nature is now common practice in Europe and Central Asia, further streamlining and harmonization is needed to reduce differences in methodologies applied, which make data aggregation and comparison difficult. The quality of data reported suggests that countries need to further develop or complement their inventories and monitoring schemes (EEA, 2015c; OECD, 2005). In this regard, training, education and capacity-building are important steps forward (see synthesis **Table 6.11**).

Regarding rights-based instruments and customary norms, (Varga, Heim, Laszlo, & Molnár, 2017) emphasize that conservation management practices (e.g. mulching hay meadows, shredding shrubbery) are often very different from traditional practices (Holl & Smith, 2002), as conservation managers’ education is almost exclusively based on western science (Primack, 2010). At the same time, the ability of traditional ecological knowledge holders to protect their rights and to advance their own interests is relatively low (Heikkinen, Sarkki, & Nuttall, 2012). Policy instruments to reinforce the role indigenous peoples and local communities may include: strengthening the capacities of national human rights institutions; ensuring that national laws are harmonized with international human rights treaty standards; legislation with the purpose of defining property rights or access right to land; collaborative arrangements where the participation of indigenous groups and local communities are secured; and the implementation of mechanisms for free, prior and informed consent. Despite the fact that emerging and new approaches have contributed to changes with respect to indigenous rights and nature conservation, there are a number of challenges and difficulties in combining indigenous values with the views of western understandings of conservation (Elenius et al., 2017).

6.4.2 Environmental governance for biodiversity and nature’s contributions to people: synergies and trade-offs

6.4.2.1 Key environmental policies

In addition to the nature conservation policies described in Section 6.4.1, a broad range of environmental policies shape changes in biodiversity and nature’s contributions to people, notably those addressing water quality and quantity (both marine and freshwater), flood management, air and wider environmental pollution, waste management, mitigation of, and adaptation to climate change, soil management and land degradation. These policies complement, overlap and intersect with policies in other sectors, for example, on agriculture, forestry, fisheries, resource extraction and energy (Section 6.5). In many cases, such environmental policies are intended to constrain land use practices and abstraction of natural resources to safeguard environmental quality. While the general objective

of these environmental policies is thus by definition to improve environmental quality, including the provision of nature's contributions to people, three main questions emerge. First, there might be implicit trade-offs between managing for different ecosystem services and/or biodiversity-related goals, for example, related to biofuel targets (Tosun & Schulze, 2015) or water management and biodiversity conservation (Beunen, van der Knaap, & Biesbroek, 2009): How do environmental policies deal with these conflicts, which ecosystem services are favoured, and which are negatively affected? Second, policies do not always achieve their intended aims, often due to a lack of enforcement or insufficient alignment across sectors: What are the *de facto* implications of the existing environmental policies for biodiversity and ecosystem services? Third, what are the options that emerge from this analysis to improve environmental governance in the future? This section concentrates on these questions, building on the presentation of international, regional and transboundary governance arrangements that address environmental challenges (Section 6.3) and providing the backdrop for the analysis of sectoral policies (Section 6.5).

In the European Union, there is a widespread perception that, in terms of the adoption and effectiveness of environmental policies, a lot of progress has been made over recent decades (EEA, 2015d; IEEP, 2013; Selin & VanDeveer, 2015), but that the challenges ahead are enormous (e.g., related to climate change), and that efforts therefore need to be sustained (EEA, 2015d). There is a recognition that societal-level transformations are needed rather than just gradual or very specific changes, i.e. that current lifestyles and associated expectations and value systems have to significantly change. However, the political and societal drive for economic growth and prosperity still does not tend to align with environmental aims and objectives, despite increasing efforts to identify win-win situations (e.g., IEEP, 2013). The recognition of this challenge has led to the incorporation of notions of societal change towards sustainability into environmental policy goals, blended with a language that is seen as compatible with economic thinking, using terms such as “natural capital” and “nature-based solutions”. In this respect, policies are more than just sets of rules; they shape and are shaped by discourse and ways of thinking. Partly because of this realization, recent environmental policies in the European Union tend to adopt a much more systemic perspective than they previously did, grouping policies into larger packages rather than addressing single issues (EEA, 2015d; Hüesker & Moss, 2015). For example, the idea of a “circular economy” has been introduced to shape and provide the conceptual umbrella for strategies to deal with resource use and waste (EEA, 2015d; Lazarevic & Valve, 2017), while the “low-carbon society” provides direction to policies targeting the mitigation of climate change (EEA, 2015d) (see also **Box 6.2** for an example influenced by the “ecosystem approach”). However, Bouwma et al. (2017) suggest that within the body of European Union environmental law (the “acquis”, which consists of more than 500 directives, regulations and decisions; (EEA, 2015d); see Section 6.3 for an overview of the most important directives) the concept of ecosystem services has not yet been fully mainstreamed beyond those policies that focus on nature or natural resources.

Box 6.2: Scotland's Land Use Strategy 2016-2021

Although the United Kingdom has been characterized as having a strongly hierarchical approach to governance (Pierre, 2000), recent developments in the devolved administration in Scotland suggest a move to a more networked approach, characterized by steering instruments providing strategic direction. A good example of this is the Scottish Land Use Strategy (Scottish Government, 2016). The strategy was initiated as an action arising from the Climate Change (Scotland) Act 2009, and has recently been refreshed for a second five-year period. The Land Use Strategy encompasses all land in Scotland, both rural and urban, and is therefore a cross-sectoral and integrative steering mechanism to encourage a more holistic approach to land use planning and practice. One of its guiding principles is the adoption of an Ecosystem Approach (Waylen et al., 2014), promoting recognition of natural functions, working with nature's contributions and engaging people. The approach focuses on providing a strategic framework for voluntary action at local, regional and national scales. Recent pilots of a Land Use Strategy regional framework, in the Scottish Borders and Aberdeenshire, have illustrated the benefits of spatially

explicit evidence of trends in ecosystem service delivery; the ability to explore possible future trajectories; and public engagement to determine what people want from their land and the best ways to achieve it (Davidson et al., 2015). The pilots confirmed that while some win-win solutions are available, often land-use change involves difficult choices surrounding trade-offs. Overall, the approach made impacts of land-use decisions on biodiversity and other regulating ecosystem services more visible. The deliberations, that were part of the approach, helped stakeholders from diverse sectors to appreciate the distribution of impacts and to better understand the basis for differences in preferences about land use and land-use change. However, achieving material improvements to the integrated management of land still requires a combination of incentives and sanctions to prop up this strategic steer. Whilst the pilots illustrated the promise of the approach, there was no actual implementation of the approach beyond the pilots. Therefore, the pilots illustrated both substantive and instrumental advantages of participatory processes (see Section 6.6), but support of other policy instruments is required to achieve benefits for ecosystems and biodiversity (Verburg, Selnes, & Verweij, 2016). The Land Use Strategy has a policy to develop a network of regional land use partnerships in order to stimulate this deliberative and systems-orientated approach to land use across the whole of Scotland.

End of Box 6.2

In Eastern Europe and Central Asia, and in Central European countries outside the European Union, the overall picture appears to be more ambivalent. There is recognition that the region is very diverse and that a lot of progress has been made in recent years (OECD, 2012a; UNECE, 2015a, 2015b, 2016a, 2016b) compared with previous, much more negative assessments (OECD, 2005). However, the effectiveness of environmental policies still seems heavily dependent on legacies in the governance systems of these countries (Carmin & VanDeveer, 2005; Winqvist & Wolf, 2013) and their interactions with approaches adopted more recently (Agarin & Grīviņš, 2016). Framework legislation on environmental issues in these countries underwent a reform process in the 1990s and 2000s (OECD, 2005), and many countries have subsequently developed more detailed regulations and action plans (Winqvist & Wolf, 2013). In Central Asia, but also in Eastern and Central Europe, donor support and international assistance (see e.g., <http://www.naturalresources-centralasia.org/>) have played a strong role in the development of action plans and policies (OECD, 2005, 2012a; UNECE, 2015a). However, such reforms are not necessarily effective yet and have sometimes been compromised by subsequent interventions. In Georgia, for example, a reorganization of the environmental authorities in 2011 involved substantial cuts in budget and staff. Although partly reversed in 2013, these cuts still had longer-term impacts on institutional capacities (UNECE, 2016b). By comparison, in Serbia, new environmental laws and a large number of subsidiary regulations were adopted in recent years (UNECE, 2015b). However, not all of the new legal instruments have been followed up with strategies, action plans, reporting, or other operationalization and enforcement mechanisms. Overall it appears that, even where strong pro-environmental legislation exists, consistent implementation is often still lacking and would also benefit from being streamlined across sectors (OECD, 2012a). Currently, there are many encouraging developments towards more holistic management approaches, for example, in relation to Integrated Water Resources Management (OECD, 2005) and integrated management of peatlands (Council of Ministers of the Republic of Belarus, 2015). Overarching discourses such as “green growth” (e.g., OECD, 2012a) have also been used in an attempt to work towards more integrated approaches to policymaking. However, integration of environmental policies and management approaches into broader policy contexts across sectors seems to be still in its infancy, as does inter-sectoral coordination, for example, between ministries within a country (OECD, 2005), although progress has been made recently in some Eastern European and Central Asian countries (OECD, 2012a).

31520 6.4.2.2 Governance modes and policy instruments

31521 Environmental governance modes and policy instruments (see Section 6.2 for definitions) are
 31522 extremely diverse and multi-faceted. Given the complexity and diversity of environmental governance
 31523 across Europe and Central Asia as outlined above (Section 6.4.2.1), it is only possible to present a very
 31524 selective review of the key governance mechanisms, their opportunities and constraints. The search
 31525 terms used in the literature review couched the topic as “governance”. Therefore, unsurprisingly, the
 31526 majority of the reviewed literature addressed hierarchical or decentralized governance modes and
 31527 legal, regulatory, economic and financial policy instruments. This notwithstanding, even within this
 31528 sub-segment of the literature, a wide range of governance mechanisms is described.

31529 For Eastern Europe and Central Asia, the majority of the literature focuses on hierarchical approaches
 31530 to governance, including, for example, environmental quality standards, environmental impact
 31531 assessments and permits as legal and regulatory instruments; national environmental action plans for
 31532 overarching guidance; and pollution charges, pricing and fees for the abstraction of natural resources
 31533 as economic instruments (OECD, 2005, 2012a). However, research that draws on a sociological
 31534 perspective also highlights the role that culturally shared understandings of responsibility, agency and
 31535 governance can play in shaping environmentally relevant behaviour. For example, a qualitative study
 31536 from the Kalmyk Republic, Russia, found that individuals who had participated in Buddhist teachings
 31537 had a much stronger sense of personal agency (i.e., a feeling of being able to act and change
 31538 something). Consequently, they engaged much more in small-scale pro-environmental action, than
 31539 those who adhered to a hierarchical collectivist understanding of governmental responsibility for
 31540 environmental quality (Waylen, Fischer, McGowan, & Milner-Gulland, 2012).

31541 For the European Union, Bomberg (2007) describes how market-based instruments, informational
 31542 schemes and voluntary agreements gained in importance in environmental policy during the 2004
 31543 round of accessions. These are often not obligatory, but are part of a portfolio of policy instruments
 31544 that member States are able, and sometimes actively encouraged, to use when translating framework
 31545 regulations (Section 6.3) into national or sub-national governance approaches (Bomberg, 2007). Such
 31546 “new” policy instruments might be particularly attractive for the European Union with its complex
 31547 decision-making structures that require new, creative ways of governing (Kassim & Le Galès, 2010)
 31548 (Jordan et al., 2013). More recent arrangements have been even more multi-faceted and integrative,
 31549 but the guidance collaboratively elaborated through such interactive approaches still needs to be
 31550 complemented by additional enforcement and incentive mechanisms in order to be effective (**Box 6.2**).
 31551 From the viewpoint of environmental psychology, the role of social norms and other social factors in
 31552 shaping environmentally relevant behaviour, such as climate-relevant behaviour, has been evidenced
 31553 for many societies in Western, Central and Eastern Europe (e.g., Nyborg et al., 2016).

31554 Environmental governance is often nested, especially in the European Union. In other words,
 31555 instruments interact with each other across multiple levels, often with those at higher levels acting as
 31556 an umbrella for those lower down. For example, the European Union Water Framework Directive
 31557 (WFD), as one way of achieving good status for surface and groundwater, requires member States to
 31558 identify river basin districts and related authorities, which would then develop management plans and
 31559 programmes of measures. Local and regional governance is thus embedded in national and European
 31560 Union-level governance (Jager et al., 2016). Similar structures have also been developed in non-
 31561 European Union countries such as Ukraine that share river basins with European Union countries such
 31562 as Poland and are willing to align their management approaches with those of the European Union
 31563 (Hagemann, Klauer, Moynihan, Leidel, & Scheifhacken, 2014) (see Section 6.3 for more on
 31564 transboundary cooperation). The European Union Marine Strategy Framework Directive (MSFD),
 31565 which aims to achieving good environmental status in European Union marine waters, has a similar
 31566 architecture. It defines marine regions according to geographical and ecological criteria and requires

31567 member States sharing a marine region to cooperate in developing national marine strategies (Boyes,
31568 Elliott, Murillas-Maza, Papadopoulou, & Uyarra, 2016).

31569 Overall, in the European Union countries and, increasingly, in countries in Eastern Europe and Central
31570 Asia (OECD, 2005), the role of multi-actor environmental governance is recognized (Arts, Leroy, & van
31571 Tatenhove, 2006; Newig & Fritsch, 2009). This involves both state and non-state actors at different
31572 levels from the local to the international (Betsill & Bulkeley, 2004). For example, the Water Framework
31573 Directive explicitly demands public participation in river basin management (Jager et al., 2016). The
31574 implementation of the Directive can be regarded as co-management (Moss, 2012), i.e., management
31575 (or in many instances, governance: A. Fischer, Wakjira, Weldesemaet, & Ashenafi, 2014) that is shared
31576 between governmental and non-governmental actors. However, the terms “co-management” and
31577 “local knowledge” appear much less in the literature on the governance of non-biotic environmental
31578 issues than in relation to protected areas, wildlife, forestry or nature conservation; but also in the
31579 governance of, for example, water catchments, local ecological (and hydrological) knowledge has an
31580 important role to play (Iniasta-Arandia et al., 2015; Mustonen, 2013).

31581 Private and civil society actors such as environmental NGOs and industry representatives can also
31582 potentially shape the implementation of legislation through lobbying (Selin & VanDeveer, 2015), as
31583 shown for the adoption of European Union biofuel targets in both European Union member States,
31584 and non-member States in Eastern Europe (Tosun & Schulze, 2015). Similarly, international
31585 environmental NGOs can significantly influence the adoption process of new environmental policy
31586 instruments such as financial instruments and voluntary action in new accession states (Bomberg,
31587 2007). The effects of their engagement can, however, be complex and are not necessarily always
31588 positive for ecosystem services (Section 6.3.2; Agarín & Grīviņš, 2016). Together with the increasingly
31589 nested nature of governance structures that is inherently multi-levelled, such multi-actor approaches
31590 to polycentric governance may span all levels from the international to the local, as described for
31591 climate governance (Jordan et al., 2015) and for policy networks around the European Union mercury
31592 policy (Adelle, Jordan, & Benson, 2015).

31593 Economic and non-economic policy instruments interact with each other, often across sectors, but
31594 often with environmentally adverse effects. For example, the OECD’s report on “green growth” (OECD,
31595 2012a) points out that in several Eastern European and Central Asian countries, the low financial price
31596 attached to pollution and the use of energy or water, subsidies that encourage environmentally
31597 harmful practices, and regulations that set environmental standards on the basis of dated technology
31598 work together to counteract general government priorities such as energy efficiency and renewable
31599 energies. The same can be said about the multiple formal and informal institutions that work against
31600 a societal transition to a low carbon economy in the European Union, a declared policy objective
31601 (European Commission, 2016a). Improvements in environmental policy integration, notably the
31602 explicit integration of environmental policy issues into all phases of policy development and
31603 implementation, could help to address this (Beunen et al., 2009).

31604

31605 *6.4.2.3 Constraints and opportunities*

31606 One of the key factors that constrain the effectiveness of existing environmental governance
31607 arrangements is their limited enforcement, which is affected by a range of circumstances. For example,
31608 the existence of a large informal (shadow) economy in many Eastern European and Central Asian
31609 countries means that governance instruments such as taxation or pollution charges can influence only
31610 a limited proportion of all economic activities. At the same time, a complex regulatory framework
31611 might deter some economic actors from moving from the informal to the formal sector (OECD, 2012a).
31612 Improvements to those environmental governance arrangements that might be seen as overly

31613 complicated could facilitate this move (OECD, 2012a). In their systematic review of studies evaluating
 31614 low-carbon policies, (Auld, Mallett, Burlica, Nolan-Poupart, & Slater, 2014) find a major trade-off
 31615 between the efficiency of policies and their accountability and impact. Notably, they found that
 31616 voluntary agreements tended to be less costly and more efficient than government-led instruments,
 31617 but at the same time, accountability and effectiveness were limited, as they were lacking compliance
 31618 mechanisms and clearly assigned responsibilities. Similar patterns might be found in the Water
 31619 Framework Directive (Voulvoulis, Aron, & Giakoumis, 2017).

31620 Effectiveness of existing governance mechanisms is also limited by the sheer size of the environmental
 31621 impact of human activities. Although this is not often stated explicitly, it seems that even progressive
 31622 governance approaches such as the European Union Water Framework Directive are often not able to
 31623 achieve environmental policy objectives, especially in areas of intensive agriculture and high
 31624 population densities such as in parts of Western and Central Europe. Addressing these shortcomings
 31625 requires, at the very least, an even more integrated and cross-sectoral approach to land and resource
 31626 management (EEA, 2015d).

31627 Challenges associated with quantifying the targets within environmental policies make effective
 31628 implementation difficult. For example, European Union member States have found it difficult to define,
 31629 in a manner that is measurable, what is meant by “good environmental status” in the context of the
 31630 Marine Strategy Framework Directive. In the absence of a clearly defined good environmental status,
 31631 it is not always possible to measure the impacts on, or risks to, the marine environment. Furthermore,
 31632 the definition of good environmental status and its indicators are generally left to the interpretation
 31633 of the individual member States, which may lead to variation in implementation (Boyes et al., 2016).
 31634 Economic considerations are also central for developing the marine strategies required by the Marine
 31635 Strategy Framework Directive as well as the Water Framework Directive. For example, cost
 31636 effectiveness analysis and cost benefit analysis have to be carried out before the implementation of
 31637 any new measure to reach good environmental status under the Marine Strategy Framework Directive.
 31638 These economic assessments can play a major role in justifying exceptions from the requirement to
 31639 reach good environmental status, but their meaningfulness is limited when there is ambiguity
 31640 surrounding the definition of good environmental status as the target state (Bertram, Dworak, Görlitz,
 31641 Interwies, & Rehdez, 2014).

31642 Effectiveness might also be constrained by limited encouragement for innovation within the existing
 31643 policies. For example, existing pollution charges in Eastern Europe and Central Asia are often low and
 31644 based on present technological standards, thereby missing out on the opportunity to incentivize
 31645 technological improvements, for example, in terms of energy efficiency. Substantial subsidies for fossil
 31646 fuel use in both businesses and households counteract intentions to move to a low carbon economy
 31647 (OECD, 2012a). Generally, policies that leave scope for flexibility to choose from different options and
 31648 pathways to achieving the same goal, for example, to reduce greenhouse gas emissions, tend to be
 31649 more efficient and procedurally superior to narrower and more rigid instruments. However, if policies
 31650 offer too much flexibility (and thus loopholes), they might defeat their own purpose, or have negative
 31651 side-effects on social objectives such as equity (Auld et al., 2014). However, the incentive character of
 31652 governance approaches (i.e., the degree to which these act in an encouraging way) also has to be
 31653 considered for participatory approaches. In the Water Framework Directive, participatory processes
 31654 lack political power. In the long term, this may make it difficult to encourage public participation in
 31655 further processes, damage public trust in authorities and undermine the legitimacy of plans and
 31656 measures (Jager et al., 2016).

31657 Environmental or ecological fiscal reform aims at redirecting a government’s taxation and expenditure
 31658 programmes to create an integrated set of incentives to support the shift to sustainable development
 31659 (National Round Table on the Environment and the Economy, 2002). It refers to a range of taxation

and pricing measures that can raise fiscal revenues while furthering environmental goals. This means that taxation schemes are designed in a way that they place the tax burden on environmentally undesirable activities, rather than on those that might be environmentally desirable. Such schemes have to be carefully developed to be fiscally and environmentally effective, administratively feasible, and to avoid disadvantaging those actors that are already disadvantaged. For example, taxation can have both direct positive and negative impacts on money available in a household, as well as indirect impacts on employment or access to resources. Earmarking tax revenue to support pro-environmental activities can help to implement new governance tools that require financial resources (such as payments for environmental services), but can also obscure the overall governmental budgeting process and decrease transparency and accountability (OECD, 2013b). To focus their impact, taxes on environmentally harmful behaviour can be combined with subsidies for less harmful options. Again, however, these need to be carefully designed to avoid constraining alternative pathways of innovation (Pfaller, 2010). Although attempts have been made to develop environmental taxes in several countries, there remains substantial potential for more profound reforms and increased effectiveness (see also Chapter 4, Sections 4.3.2, 4.4.4, 4.4.5) (Ludewig, Meyer, & Schlegelmilch, 2010; Pfaller, 2010). More recently, the concept of ecological fiscal reform has been expanded to address land-use issues, biodiversity conservation and ecosystem services provision and thus, towards rewarding environmentally-friendly behaviour by way of fiscal instruments such as ecological fiscal transfers (Ring, 2011; UNDP, 2017).

Increasing effectiveness through economic instruments is a challenge that needs to be complemented by non-economic approaches. Prices attached to resource use or abstraction (e.g., water, energy) need to consider effects on poorer parts of the population. Increasing the price of energy and water has implications for the affordability of these resources among poorer households. The key challenge is to improve both efficiency and economy of use in a way that is pro-poor. This can happen through economic instruments, such as differential tariffs for industrial and domestic customers as in Moldova (OECD, 2012a) or progressive taxes and compensation measures for poorer households (OECD, 2013b), but other, non-economic instruments need to contribute here, too.

Integration of resource management might cause tensions in terms of the appropriateness of governance level and “institutional fit” (Newig & Fritsch, 2009). For example, Integrated Water Resource Management, and thus the river basin management approach adopted in the Water Framework Directive, can be seen as a positive development as it moves beyond single-issue policies. However, the conclusion that governance of a river basin should be based on the corresponding hydrological unit can lead to institutional misfits in other regards as river basin management is not solely a hydrological issue (Jager et al., 2016; Moss, 2012).

Integration and implementation of novel governance approaches often remain incomplete, and therefore ineffective. For example, in the case of the Water Framework Directive, many member States have opted to retain existing structures and procedures as far as possible, without transferring responsibilities and power to the new river basin authorities (Jager et al., 2016). Member States often continue with traditional water management practices focused on specific pollutants, rather than addressing catchment governance in a systemic way. Programmes of measures are often not implemented, which compromises delivery of Water Framework Directive objectives (Voulvoulis et al., 2017). The flexibility conceded to member States in the Water Framework Directive might thus hamper its effectiveness.

Changes in governance arrangements instigated by intentions of European Union alignment or accession – even if long-term and aspirational, or if accession is not aimed for – are often regarded as opportunities for improving environmental governance (Juelich, 2005; Rosell Perez, 2013). Organizations like the Energy Community can be seen as facilitating steps towards such alignment

(Tosun & Schulze, 2015). While substantial progress has been made overall (EEA, 2015d), in many cases further steps need to be taken to make policy change really effective (Juelich, 2005; Rosell Perez, 2013). For example, the Ukraine has modified legislative and regulatory instruments for water quality and monitoring both in response to guidance from the United Nations Economic Commission for Europe and European Union policies (Hagemann et al., 2014). In Serbia, the process of adopting the European Union environmental acquis has also progressed, but this rather complex task has been hampered by a lack of staff to develop the necessary legislation (UNECE, 2015b) (see also UNECE, 2015a on Montenegro).

However, institutional change, even if intentional and planned (A. Fischer, Petersen, Feldkötter, & Huppert, 2007) might be much less linear and direct than expected (Cleaver, 2002). For example, Waylen and co-authors (Waylen, Blackstock, & Holstead, 2015) identify the impacts of institutional, cognitive and political “sticking points”, i.e., legacy effects, on the development of natural resource management initiatives working towards the adoption of an ecosystems approach. Kasymov and co-authors (Kasymov, Undeland, Dörre, & Mackinnon, 2016) describe how in Kyrgyzstan, the revision of legislation that governs pasture use by livestock herders was based on a learning process that included trial and error (see also Section 6.5.1.2). They stress that such joint learning processes that allow for adaptation in a dynamic world should be seen as positive and an opportunity to develop governance arrangements that work on the ground. However, they also recognize that any such arrangements were (by-)products of larger policy discourses, such as the Washington Consensus that gave primacy to privatization and decentralization in the early stages of the revision process, and later ideas of community-based resource management and inter-sectoral cooperation.

6.4.2.4 Summary

While assessing the relevant bodies of literature on environmental governance, the diversity of existing governance arrangements and opportunities for the future in Europe and Central Asia, a number of knowledge gaps became apparent.

First, there seem to be limited studies that take a multidisciplinary systemic perspective on environmental governance in the region, and that combine an analysis of policy instruments with an analysis of the behaviour of (economic) actors (e.g., households, companies) and the overarching economic and social system in which these behaviours are embedded. Such perspectives would provide insights into the root causes of the limited effectiveness of environmental governance.

Second, while there is some literature that comments on the effectiveness of environmental governance arrangements, few publications assess their implications for equity and environmental justice. There are also very limited comparative insights into the effectiveness and ways of working of alternative policy instruments, and their interactions with each other in context (Jordan et al., 2013).

Third, analyses that trace the impacts of governance arrangements on biodiversity and ecosystem services (or nature’s contributions to people) in some depth, and that report on synergies and trade-offs or conflicts between their impacts, are very scarce (see **Box 6.2** for an exception). For example, more research is needed on the interplay between the different European Union directives dealing with the natural environment (Boeuf & Fritsch, 2016). Synergies are sometimes assumed but are not necessarily an explicit topic of investigation.

Fourth, and perhaps to some extent an artefact of the search process applied, literature on environmental governance seems to be largely focused on policy instruments and formal institutions. For the environmental sector, much less research and analysis is available on informal and hybrid governance mechanisms such as co-management and public-private partnerships. In particular, there

are very few analyses of governance as a process (rather than an assemblage of institutions) in Eastern Europe and Central Asia, and analyses of local governance mechanisms and the role of local knowledge in environmental issues beyond water management.

Keeping these knowledge gaps in mind, our overview suggests that overall, the governance literature focuses predominantly on hierarchical governance modes as opportunities for improvements, rather than on public-private partnerships or private and civil society governance. This is especially true for publications like those of the OECD and other reports that might be informing policymakers' views more directly than academic journal papers. This is positive, as it does not shift responsibilities away from governmental actors by putting the onus of delivery on citizens who might not be equipped for the task. Such tendencies, labelled "the neoliberal agenda" have been widely criticized elsewhere, for example, in the context of rural development and community empowerment (MacKinnon & Derickson, 2012). A strong reliance on civil society to effect larger change, for example, a transition to a low-carbon society, will also miss out on the power of hierarchical governance approaches (A. Fischer et al., n.d.). However, businesses and corporations also bear significant responsibility for such a transition. Finally, a stronger consideration of a wider set of governance modes and instruments that includes grassroots action and social and information-based instruments might help to make environmental governance both more resilient and more effective (Seyfang & Smith, 2007; Stirling, 2014).

6.5 Sector policies and instruments: key constraints and opportunities

6.5.1 Agriculture

6.5.1.1 Policy objectives in Western and Central Europe

In Western and Central Europe, the Common Agriculture Policy (CAP) exerts a great influence on agricultural land and rural areas of the European Union member States. Since its inception in the early 1960s, the overall objective of the Common Agricultural Policy was to enhance agricultural production. This has been achieved mainly through a market and price policy, subsidizing production and regulating import and export (EEA, 2016; European Commission, 2004; Hodge, Hauck, & Bonn, 2015; Zanten et al., 2014). Production, reaching a peak in the mid-1980s, led also to the destruction, stocking, or dumping of agricultural surplus in developing countries, and to the increase of Common Agricultural Policy expenditures to around 70-75% of the total European Union budget (European Commission, 2004, 2013a). Unfortunately, the increase in production and productivity, achieved through agricultural intensification (e.g. by chemical inputs and mechanization), undermined other nature's contributions to people such as the provision of water quality, soil erosion and water run-off control, conservation of species and habitats, and maintenance of traditional agricultural landscapes and cultural identities (see also Chapter 2) (EEA, 2015a, 2015b; Henle et al., 2008; Stoate et al., 2009; Zanten et al., 2014).

Recognizing the economically, socially and environmentally unsustainable model of the Common Agricultural Policy, reforms were undertaken in 1984, 1992, 1999, 2003, 2008 and 2013. The overall objectives of these reforms were: changing the policy from a production support system to one more suitable to adapt to market conditions in a system of liberalization of world trade; reducing agricultural surplus; keeping budget costs stable and manageable; and making the policy more flexible and better shaped to the social, economic and environmental needs and conditions of different rural areas. The 1992 Common Agricultural Policy reform introduced some accompanying measures such as Reg. 2080/92 on forestry, Reg. 2078/92 on agri-environmental measures, the set aside of arable land, and

the marketing of quality products. Then Reg. 1257/99, and later Reg. 1698/05, unified in one Regulation for Rural Development, bringing together a number of structural and accompanying measures and disciplines. The 2003 reform introduced de-coupling of payments from agricultural production and structured the Common Agricultural Policy into two pillars: the first addressing the common market organization (i.e. agricultural commodities), the second focusing on rural development and delivering of public goods. Cross-compliance⁴⁰ by farmers, was made compulsory to render them eligible for direct payments of pillar 1 by the 2003 Reform, envisaging also the transferring of funds from pillar 1 to 2 (i.e. modulation). In pillar 2 new measures were introduced for management practices of agricultural land compatible with the conservation of the environment and biodiversity (e.g. Natura 2000 payments).

The main objectives of the last 2013 Common Agricultural Policy reform were: 1) to ensure long-term food security for people in Europe and to contribute to the growing global demand for foodstuffs; 2) to sustainably produce diversified, high-quality food while conserving natural resources and biodiversity; and 3) to ensure the viability of rural areas (European Commission, 2013c). This reform has seen the reduction of pillar 1 funding by about 13% and of pillar 2 funding by about 18% compared with the previous programme period 2007-2013 (Pe'er et al., 2014). Another objective of this reform was to further enhance the joint provision of private and public goods by increasing the integration of pillar 1 and 2 in a more targeted, efficient and complementary way (European Commission, 2013c). For example, this included the introduction of the mandatory greening component (making up 30% of direct payments under Common Agricultural Policy pillar 1) conditional on the adherence of farmers to three “greening requirements”⁴¹.

6.5.1.2 Governance modes and policy instruments in Western and Central Europe

The policy instruments implemented by the Common Agricultural Policy cover almost all governance modes applied to the agricultural sector: hierarchical (e.g. directives and regulations), decentralized (e.g. rural development plans), public-private governance (e.g. agri-environmental measures contracts between national or local public administrations and farmers) and private (e.g. agricultural markets) governance modes.

Among the most relevant regulatory instruments used by the Common Agricultural Policy, are the cross-compliance and greening requirements and European Union Directives concerning environmental issues. The European Union Water Framework Directive (2000/60/EC) (WFD) and the Nitrates Directive (91/676/EEC), are implemented by the Common Agricultural Policy through cross-compliance requirements such as “*protection and management of water*” and to “*protect water against pollution and run-off and manage the use of water*” (Matthews, 2013). Under the Habitats (Directive 92/43/ECC) and Birds Directives (Directive 79/409/EEC amended in Directive 2009/147/EC), there are 57 types of habitats and 259 species recognized as depending on or somehow linked to the continuation of agricultural practices (European Commission, 2014a). The Framework Directive on the Sustainable Use of Pesticides (Directive 2009/128/EC) delegates to member States the delivery of

⁴⁰ Cross-Compliance comprises Statutory Management Requirements (SMR), referring to standards in environment, food security and animal welfare, and Good Agricultural and Environmental Conditions (GAEC) referring to soil protection, maintenance of soil organic matter and structure, avoiding the deterioration of habitats and water management (Commission Regulation (EC) No 1122/2009).

⁴¹ The three greening requirements are: 1) to cultivate at least two or three different crops in case of arable land exceeding 10 ha or 30 ha, respectively ; 2) to maintain permanent pasture; and 3) to establish ecological focus areas on at least 5% of arable land exceeding 15 ha (Hodge et al., 2015).

31834 national action plans to reduce the impacts of pesticides and promote alternative techniques such as
31835 integrated pest management.

31836 **Box 6.3: Agri-environmental policy in Turkey**

31837 Agriculture in Turkey, covering around 50% of the territory, has a far greater importance for the economy than
31838 for the EU-28. In 2012 agriculture in Turkey accounted for around 9% of GDP and 23.5% of total employment
31839 compared with 1.6% and 5%, respectively, in the EU-28 (European Commission, 2014d). Turkish farm structure
31840 is largely characterized by small farms, most of which are managed by families employing family labour, and
31841 practicing semi-subsistence agriculture (European Commission, 2014d).

31842 In the last decades of the 20th century, the agricultural sector in Turkey was heavily influenced by government
31843 interventions such as the management of commodity prices through purchases and sales (e.g. cereals, sugar and
31844 tobacco), import tariffs and export subsidies, subsidized farm inputs (e.g. chemical fertilizers, diesel), and credit
31845 and investments in irrigation and other infrastructure (Larson, Martin, Sahin, & Tsigas, 2014). Since 2001,
31846 following loan agreements with the International Monetary Fund, the Agricultural Reform Implementation
31847 Project (ARIP) was undertaken to change the commodity price support into "farm direct income support" de-
31848 coupled from production (Akder, 2007; Tan, Atak, Üengül, & Sami Tan, 2015). The resulting intensification of
31849 agriculture has caused on the one side, in the decade between 2003 and 2013, an annual wheat production of
31850 around 20 million tons (Tan et al., 2015) and on the other, the loss of genetic diversity as testified by the low
31851 share (under 1%) of local wheat landraces in the total area of wheat production (FAO, 2015). Other
31852 environmental problems are related to soil erosion, over-consumption and waste of water, and excessive use of
31853 chemicals (Republic of Turkey, 2012). Unfortunately, although environmental issues in agriculture have been
31854 addressed by the Turkish Government since the 1990s, and are supposed to be increasingly considered by
31855 following the adoption of the Acquis Communautaire in the pre-accession process (Republic of Turkey, 2012),
31856 the implementation of agri-environmental schemes is still in its infancy. Protection of the environment is mainly
31857 pursued through regulations while agri-environmental measures are still promoted only at a preparatory and
31858 pilot level, and organic agriculture has so far developed through export markets without any significant
31859 government support (Republic of Turkey, 2012).

31860 There are clearly opportunities for improvement of agri-environmental policy, particularly considering that
31861 Turkey has an enormous potential to promote sustainability in agriculture because of a great richness of
31862 biodiversity and yet unexploited agro-ecosystems resulting from traditional extensive farming practices. Because
31863 of its geographical position, many fruit species, such as cherries, apricots, almonds and figs, originated in Turkey
31864 as well as wild relatives of other cultivated species such as wheat, chickpea, lentil, apple, pear, chestnut, hazelnut
31865 and pistachio (Republic of Turkey, 2012). Because wheat cultivation has been carried out for more than 8,000
31866 years in Turkey, beside wild relatives and semi-domesticated varieties there is a large number of wheat landraces
31867 (FAO, 2015).

31868 **End of Box 6.3**

31869 The most important economic and financial policy instruments are direct payments (i.e. basic
31870 payments and the greening payments) (pillar 1) and rural development measures (pillar 2). In the
31871 financial year 2013 direct payments from pillar 1 amounted to 71% of the whole Common Agricultural
31872 Policy expenditure showing an increase from 61% in the financial year 2000 and 65% in the financial
31873 year 2005, mainly due to new member States joining the European Union (European Commission,
31874 2014b). The level of direct payments differs between countries and farmers because they are
31875 calculated as compensation for support-price reduction taking historical production and past income
31876 support as reference. This has resulted in large productive farms receiving more payments than small
31877 ones, creating problems with distribution and social cohesion (European Commission, 2014b). For the
31878 period 2014-2020, 118 rural development plans with economic, environmental and social objectives
31879 for pillar 2 have been proposed by national or local administrations on the basis of European Union
31880 Reg. 1305/2013 and co-funded by the European Agricultural Fund for Rural Development (EAFRD).
31881 Agri-environmental-climate payments are allowed for farmers voluntary enrolling for a minimum

31882 period of 5-7 years and for practices going beyond cross-compliance and greening requirements. Agri-
 31883 environment payments are estimated on the basis of additional costs and income foregone, resulting
 31884 from the commitments to be undertaken by farmers. An additional payment can be granted to cover
 31885 transaction costs up to 20% of the payment, or 30% in the case of commitments undertaken by a group
 31886 of farmers. The spending for agri-environmental measures for the period 2014-2020 is foreseen to
 31887 reach 25 billion Euro (European Commission, 2015a).

31888 Rural tourism is a private sector activity driven by market demand with important linkages to cultural
 31889 and territorial local identity, often resulting in diversification of small and medium farms' activities.
 31890 Rural tourism represents 10-20% of rural income and employment (European Parliament, 2013). Some
 31891 rural development measures such as, for the period 2007-2013, 'encouragement of tourism activities',
 31892 and "conservation and upgrading of rural heritage" and the LEADER initiative promoting integrated
 31893 and synergic development based on the endogenous resources of rural areas (European Commission,
 31894 2013d), support the maintenance of aesthetic qualities of the traditional landscape, which is a public
 31895 good (Brelík, Kutyk, & Brelík Piotr Kutyk, 2014; Papageorgiou & Guitton, 2009).

31896 Concerning social and information-based instruments, three European Union schemes, as part of the
 31897 European Union food quality policy (Reg. (EU) No 1151/2012), directly link agricultural products and
 31898 foodstuffs to stages of production, processing and preparation in a specific geographical area (namely
 31899 protected designations of origin (PDO) and protected geographical indications (PGI)); and to traditional
 31900 composition or means of production (traditional specialties guaranteed (TSG)). By promoting and
 31901 protecting agricultural products and foodstuffs, these schemes also contribute to the maintenance of
 31902 cultural heritage related to local gastronomic specialties and associated traditional agricultural
 31903 landscapes and agro-biodiversity (i.e. local animal breeds and plant varieties) (Bérard & Marchenay,
 31904 2006).

31905 In the European Union the conservation of traditional agricultural landscapes is crucial to retain local
 31906 cultural identities and to achieve the EU 2020 Biodiversity Strategy targets (Beaufoy & Cooper, 2009;
 31907 EEA, 2012b). The concept of "High Nature Value Farmland"⁴² was developed in the early 1990s
 31908 (Beaufoy & Cooper, 2009) and was adopted as an environmental indicator for the Common Monitoring
 31909 and Evaluation Framework (CMEF) of the Common Agricultural Policy in the 2007-2013 programming
 31910 period (see **Figure 6.6** below). It is included among the priorities and targets for rural development to
 31911 be addressed by the measures of pillar 2 and proposed by the European Commission also for the period
 31912 beyond 2013 (EEA, 2012b).

⁴² "Three types of HNMF are identified: Type 1: Farmland with a high proportion of semi-natural vegetation; Type 2: Farmland with a mosaic of low intensity agriculture and natural and structural elements, such as field margins, hedgerows, stone walls, patches of woodland or scrub, small rivers etc.; Type 3: Farmland supporting rare species or a high proportion of European or world populations" (European Commission, 2014a).

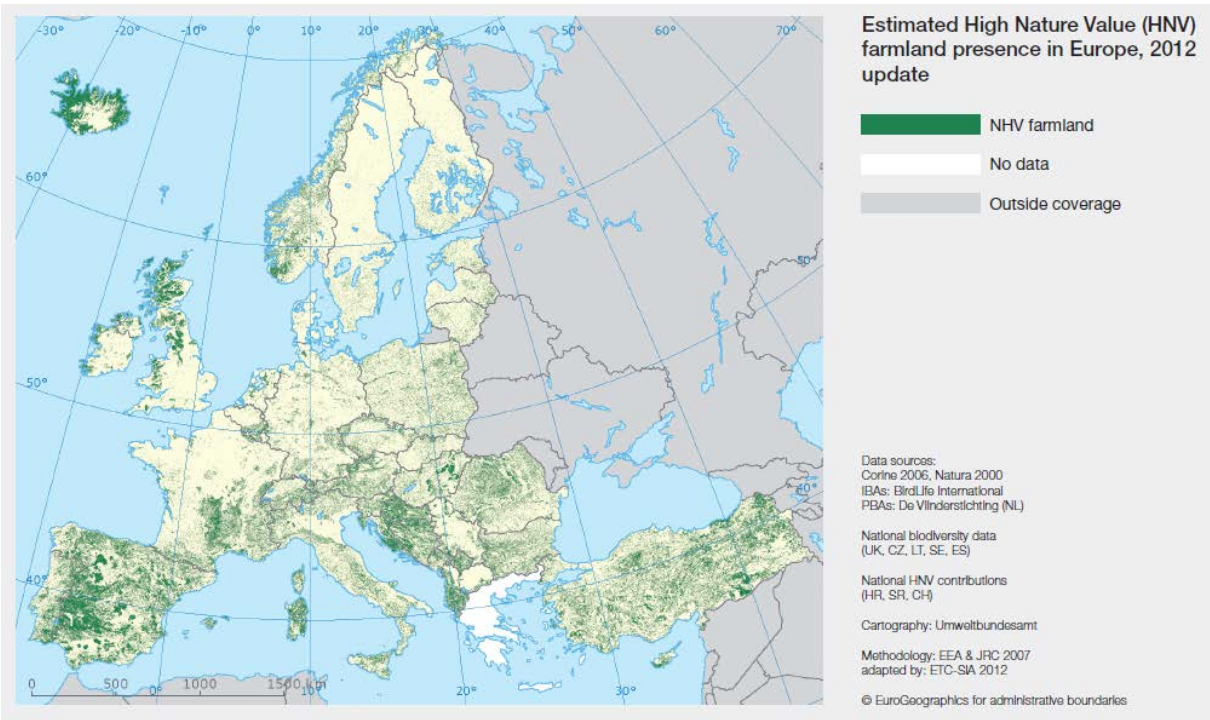


Figure 6.6: Distribution of high nature value farmland (HNVF) in Western and Central Europe 2012 (Greece not included). Source: (EEA, 2015b)

Indigenous local knowledge and practices are among the most important factors in managing high nature value farmland (Babai et al., 2015; Iniesta-Arandia, García-Llorente, Aguilera, Montes, & Martín-López, 2014). Biodiversity-rich landscapes are the result of traditional agricultural practices and local socio-economic features such as labour-intensive management and low mechanical and chemical inputs, small rotational parcel systems, mixed crops-forests-grazing systems, subsistence agriculture, traditional local knowledge, norms and institutions (J. Fischer, Hartel, & Kuemmerle, 2012; Zsolt Molnár et al., 2016). Unfortunately, while some Common Agricultural Policy instruments support general extensive management practices, the majority are not well suited to, or implemented by, particularly, Central European countries, to support indigenous and local knowledge and practices of small and semi-subsistence farms in high nature value farmland (Sutcliffe et al., 2015).

6.5.1.3 Constraints and opportunities in Western Europe and Central Europe

In this sub-section, the assessment of constraints and opportunities is carried out by following categories of policy instruments. **Table 6.6** at the end of this section summarizes the results by looking at selected contributions of nature to people.

A number of factors would increase the effectiveness, efficiency and equity of policy instruments. These include: a better definition of clear and coherent objectives for the Common Agricultural Policy, simultaneously addressing multiple ecosystem services; a more defined focus on biodiversity conservation and delivery of nature’s contributions to people at landscape level; a more explicit disclosure of trade-offs and synergies between different objectives; and more balanced and transparent funding between production of agricultural commodities and the delivery of public goods (Pe’er et al., 2014), (see also synthesis **Table 6.11**).

With regard to legal and regulatory instruments (see synthesis **Table 6.11**), both cross-compliance and greening requirements have been criticized for the general environmental requirements being too

loose to actually result in relevant ecological benefits (Hauck, Schleyer, Winkler, & Maes, 2014; Hodge et al., 2015; Pe’er et al., 2014). Cross-compliance and the effectiveness of greening requirements, and that of regulatory instruments in general, depend on baseline, land-use alternatives, farming systems and site specific ecological characteristics (Hauck et al., 2014), and on how European Union legislation is transposed and enforced by national Governments (Keenleyside, Beaufoy, Tucker, & Jones, 2014). Art. 43 of Reg. 1307/2013 on rules for direct payments envisages the possibility of member States selecting greening equivalent practices tailored to their national situation, which “*yield an equivalent or higher level of benefit for the climate and the environment*” compared with the greening requirements. However, according to Hart (Hart, 2015) this seems more an opportunity to facilitate the implementation of greening by farmers than actually increasing environmental outcomes. The actual provision of public goods by cross-compliance and greening requirements should be verified on a territorial basis and, in case of problems of effectiveness, reference levels should be adjusted locally (see also Tangermann, 2011) (synthesis **Table 6.11**). The integration of the territorial dimension in regulatory instruments is not new in European Union policy. It was already implemented in the European Union Water Framework Directive (2000/60/EC), (i.e. “good ecological status” baselines for water quality and river basins management plans) (EEA, 2015d) and in the Nitrates Directive (91/676/EEC) concerning the protection of waters against pollution caused by nitrates from agricultural sources (i.e. definition of “nitrate vulnerable zones” and implementation of farming practices following codes of good agricultural practice) (Stoate et al., 2009).

With regard to the conservation of biodiversity-rich agricultural habitats, out of 57 habitats associated with agricultural activities only 30 and 19 habitats have at least 60% and 30%, respectively, of their area included in the Natura 2000 Network. This precludes a large proportion of agricultural habitats that are rich in biodiversity from legal protection (European Commission, 2014a; Keenleyside, Beaufoy, et al., 2014). An opportunity to improve this situation is integrating biodiversity-rich agricultural habitats in the implementation of green infrastructure networks (EEA, 2014; European Commission, 2012, 2013b) (see also synthesis **Table 6.11**).

With regard to economic and financial instruments, food production has historically been heavily subsidized by the Common Agricultural Policy, at first by support prices and then, after the 1992 reform, increasingly by direct payments (Tangermann, 2011). Political justification for Common Agricultural Policy pillar 1 income support to European Union farmers are that farming is subject to volatile market prices, unpredictable weather conditions and variable input costs (European Commission, 2015a), essential to achieve food security and fundamental for the provisioning of some public goods of environmental and social character (Matthews, 2013; Tangermann, 2011). This approach has been criticized for lacking a robust rationale and clear objectives (Hodge et al., 2015; Pe’er et al., 2014). The rationale underlying the design of cross-compliance and greening requirements, to promote provision of public goods also by pillar 1, is that of having the greatest number of European Union farmers adhering to environmental requirements, so contributing to achieving positive ecological impacts and biodiversity conservation in agro-ecosystems. However, the definition of cross-compliance and greening requirements without appropriately considering local ecological and agronomic specificities, and therefore also different local opportunity costs, may result in ineffective, inefficient and inequitable policy (Matthews, 2013; Tangermann, 2011). Direct payments could be defined more transparently in terms of the income supporting objective and the ecological objective (Matthews, 2013) (see synthesis **Table 6.11**).

Amongst rural development measures of Common Agricultural Policy pillar 2, those supporting integrated pest management contribute to reducing pressures on fresh water bodies and to increasing pollination through reduced use of pesticides (Bengtsson, Ahnström, & Weibull, 2005; Tuck et al., 2014). However, the introduction of cross-compliance and greening requirements in pillar 1 makes the

31987 spending for integrated pest management (e.g. reduction and appropriate timing in pesticide use) less
 31988 justifiable (synthesis **Table 6.11**). Integrated pest management could be included amongst the
 31989 environmental requirements of pillar 1. This would free-up funds for other, more effective, agri-
 31990 environmental payments such as organic agriculture and the establishment of buffer strips along water
 31991 courses (Pe'er et al., 2014; Stutter, Chardon, & Kronvangand, 2012). It could also help fund new
 31992 measures such as the Green Infrastructure Strategy, as an innovative instrument for the conservation
 31993 of habitats favourable to biodiversity and pollinators species (Liquete et al., 2015; Pe'er et al., 2014)
 31994 (see also synthesis **Table 6.11**).

31995 Agri-environmental policy design under the European Union Common Agricultural Policy has been
 31996 largely based on action-oriented measures (i.e. farmers are required to adopt specific management
 31997 practices) horizontally implemented (i.e. valid all over the European Union agricultural land) rather
 31998 than based on results-oriented measures (i.e. compensation paid on the achievement of positive
 31999 ecological impacts) addressing specific agro-ecosystems (see synthesis **Table 6.11**). The political,
 32000 economic, ecological and social reasons for this are well understood, e.g. opportunity to enroll for the
 32001 majority of farmers, farmers acceptance, high transaction and monitoring costs of result-oriented
 32002 measures, success or failures in achieving an ecological target depending on causes other than the on-
 32003 farm management practices such as climate, diffuse pollution, or the performance of neighbouring
 32004 farms). There is also evidence to suggest that the effectiveness of action-oriented measures is lower
 32005 than of results-oriented measures (Berendse, Chamberlain, Kleijn, & Schekkerman, 2004; Burton &
 32006 Schwarz, 2013; Hodge et al., 2015; Stoate et al., 2009). In Western Europe, there is mounting evidence
 32007 from already-implemented and well-functioning result-oriented schemes (see **Figure 6.7** below)
 32008 (Keenleyside, Radley, et al., 2014; Russi, Margue, Oppermann, & Keenleyside, 2016). By adopting
 32009 result-based agri-environmental policy, measures could be targeted more towards specific agro-
 32010 ecosystems and socio-ecological systems. Contracts with farmers to deliver some of nature's
 32011 contributions to people (e.g. maintenance of particular habitat, endemic species, scenery, cultural
 32012 heritage, territorial identity) could be made at landscape level through collaborative agri-
 32013 environmental schemes (McKenzie, Emery, Franks, & Whittingham, 2013; Prager, 2015). This would
 32014 achieve critical territorial extension and reduce transaction and monitoring costs (Berendse et al.,
 32015 2004; Fleury, Seres, Dobremez, Nettiier, & Pauthenet, 2015; Zanten et al., 2014) (see synthesis **Table**
 32016 **6.11**). Moreover, results-oriented measures would also have cultural and psychological advantages.
 32017 Paying farmers for contributing to biodiversity conservation and delivering ecological services at
 32018 landscape level could enhance their environmental culture by adapting practices to local agro-
 32019 ecosystems and offering them the opportunity to demonstrate their skills, and indigenous and local
 32020 knowledge and practices in managing their farms (Burton & Paragahawewa, 2011). (See also **Box 6.4**
 32021 below and synthesis **Table 6.11**)

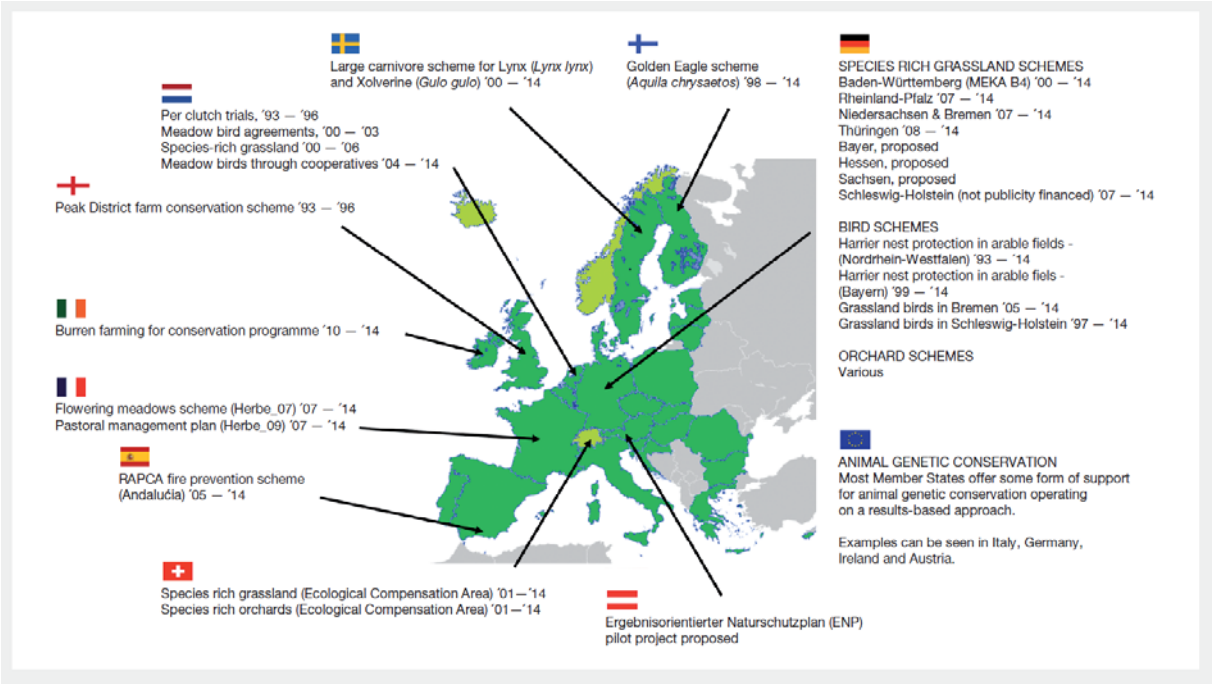


Figure 6.7: Results-oriented payment schemes in Western Europe. Source: (Keenleyside, Radley, et al., 2014).

Box 6.4: Are only economic incentives at the base of adopting ecological behaviour by farmers? The case of Switzerland

Since 1993 in Switzerland a voluntary agri-environmental scheme promoting integrated production was introduced. In 1998 the standards of integrated production became the basis of compulsory cross-compliance requirements, named “proof of ecological performance”, to be adhered to by farmers to be eligible for direct payments (Herzog, Prasuhn, Spiess, & Richner, 2008). Cross-compliance further requires animal welfare, nutrient balance, crop rotations with a minimum number of crops per farm, and the establishment of “biodiversity promotion areas” (formerly called ecological compensation areas until 2014) on at least 7% of the area of a farm (Aviron et al., 2009). Biodiversity promotion areas include extensively managed meadows and pastures, traditional high-stem fruit trees, hedges, stone walls and wildflower strips (Albrecht, Duelli, Müller, Kleijn, & Schmid, 2007; Birrer et al., 2007; FOAG, 2015; Home, Balmer, Jahrl, Stolze, & Pfiffner, 2014). The 2014-2017 agricultural policy revised the direct payment system to promote species and habitat diversity in agriculture through contributions to cultural and quality landscape, to ecological compensation, to biodiversity quality and to linking of habitats and designation of biodiversity acreages as parts of the Swiss ecological infrastructure, to production system which are in harmony with nature and animal and environmental friendly, and to resource efficient practices (FOAG, 2015).

In Switzerland, according to Aviron and co-authors (Aviron et al., 2009), cross-compliance payments amount to 20% of farms’ returns. The economic incentive of agri-environmental scheme is therefore fundamental to maintain extensive agricultural practices beneficial to biodiversity. However, to enhance the effectiveness of agri-environmental schemes by increasing BPA quality and connectivity, it is necessary also to consider other motivations of farmers to adopt more ecological behaviour. According to Home and co-authors (Home et al., 2014), for farmers in Swiss lowlands such factors, beside financial incentives, also include their personal experiences and identities, trust in the expected outcome of the scheme, and the fact that they feel somehow trapped between societal expectation to conserve nature and the pride to show productive success towards other farmers. Schenk and co-authors (Schenk, Hunziker, & Kienast, 2007) highlighted that, beside subsidies, factors such as clear information, face to face communication, active co-operation of farmers in agri-environmental scheme design and consideration of different perception of environmental problems held by authorities and farmers, are all key in the formation of long-term acceptance of nature conservation measures.

32054 Also, there is the need for a concerted effort by farmers, policymakers, NGOs and landscape planners to improve
 32055 agri-environmental schemes by addressing the specificity of more vulnerable target species at landscape level
 32056 (Aviron et al., 2009; S. Meyer, Unternährer, Arlettaz, Humbert, & Menz, 2017; von Glasenapp & Thornton, 2011).
 32057 Von Glasenapp and Thornton (von Glasenapp & Thornton, 2011) report of an ongoing Vernetzungsprojekt
 32058 (project to connect habitats and biodiversity) in Vals to incentivize farmers to adopt biodiversity-friendly
 32059 practices beyond mandatory requirements. In this project payments are negotiated on an individual basis by the
 32060 farmer and a biologist together assessing the farm biodiversity value and classifying the land into different
 32061 categories eligible for payments. The adoption of agricultural practices suitable for the land is the result of these
 32062 “walking negotiations”, enhancing the share of scientific as well as indigenous and local knowledge (von
 32063 Glasenapp & Thornton, 2011).

32064 **End of Box 6.4**

32065 A finer targeting of agri-environmental measures to the local socio-ecological context is required also
 32066 for high nature value farmland, where farms are disadvantaged by their low profitability compared
 32067 with more intensive agricultural areas and therefore depend more on Common Agricultural Policy
 32068 support measures. Unfortunately, many farms in high nature value farmland, particularly in Central
 32069 Europe, are not eligible or unable to receive direct payments from pillar 1 and agri-environmental
 32070 payments from pillar 2 (Keenleyside, Beaufoy, et al., 2014; Sutcliffe et al., 2015). This is because of high
 32071 administrative costs, small size, lack of financial capital, non-inclusion in the agricultural land
 32072 categories defined by the European Union, or insufficient payment entitlements based on low
 32073 historical support records. This situation further exacerbates the loss of indigenous and local
 32074 knowledge and the abandonment of traditional agricultural land – Central Europe (J. Fischer et al.,
 32075 2012; Zsolt Molnár et al., 2016) (see also synthesis **Table 6.11**). Besides benefiting from a better fine-
 32076 tuning of agri-environmental measures to indigenous and local knowledge, farmers managing high
 32077 nature value farmland could take advantage also of the opportunities offered by rural tourism being
 32078 attracted to traditional agricultural landscapes. Market opportunities for small to medium-sized farms
 32079 located in high nature value farmland could be further enhanced by promoting short food supply
 32080 chains such as farm direct selling of local products to visitors, farmers’ markets and e-commerce
 32081 (Simoncini, 2015), and networking of farmers.

32082 Among social and information-based instruments, information and training for farmers is crucial for
 32083 the management of biodiversity and delivering of nature’s contributions to people in farmland. The
 32084 lack of advice and training for conservation of biodiversity related to Natura 2000 has been highlighted
 32085 as a major shortcoming (European Commission, 2016c) (see also **Box 6.5** below and synthesis **Table**
 32086 **6.11**). A study reviewing the social aspects of Natura 2000 (European Commission DG Environment,
 32087 2016) found that “*the limited participation of stakeholders, the negative perceptions of the network*
 32088 *and a lack of consideration of the local context hinder the network’s effectiveness*”, and that these need
 32089 to be tackled by increasing public awareness. Advisory services on the delivery of public goods (e.g.
 32090 biodiversity, cultural, territorial and relational values generated by local food production, processing,
 32091 selling and consumption) could be enhanced (European Network for Rural Development, 2013) and
 32092 the resulting advantages for farmers and civil society clearly explained (Fleury et al., 2015) (see
 32093 synthesis **Table 6.11**).

32094 (Stoate et al., 2009) indicate that in France around 70% of the Protected Denomination of Origin
 32095 products are found in high nature value farmland. The design of an innovative eco-labelling European
 32096 Union scheme for those agricultural products coming from high nature value farmland and Natura
 32097 2000 areas, could be an opportunity to allow European consumers to contribute to biodiversity
 32098 conservation while buying traditional and high-quality food (see synthesis **Table 6.11**). However, a
 32099 strategy to enhance the sustainability of high nature value farmland should also consider non-
 32100 economic benefits such as motivations of farmers to manage high nature value farmland, their
 32101 indigenous and local knowledge and practices, their socio-ecological context and life style, and their

32102 need for social and political recognition (EIP-AGRI Focus Group, 2016; J. Fischer et al., 2012; Gómez-
32103 Baggethun & Reyes-García, 2013; Iniesta-Arandia et al., 2015).

32104 **Box 6.5: Shortcomings in the implementation of Natura 2000 payments by European Union member**
32105 **States**

32106 Agricultural land included in the Natura 2000 network covers 10.6% of utilized agricultural area of the EU-27
32107 (European Commission, 2013d). Most Common Agricultural Policy pillar 2 direct policy instruments for
32108 biodiversity and habitats conservation are Natura 2000 payments supporting areas associated with agriculture
32109 and forestry. However, in the 2007-2013 period in the EU-27, Natura 2000 payments and Natura 2000 payments
32110 linked to Directive 2000/60/EC (Water Framework Directive) comprised only 0.1% and 0.5%, respectively, of the
32111 European Agriculture Fund for Rural Development expenditures for Axis 2 of rural development on the
32112 environment (European Commission, 2013d). Consequently, this resulted in under-funding of Natura 2000 areas
32113 (Hansjürgens, Kettunen, Schröter-Schlaack, White, & Wittmer, 2011; Hochkirch et al., 2013). During the 2007-
32114 2013 programming period, only half of European Union member States included Natura 2000 payments in their
32115 rural development plans. According to the European Commission (European Commission, 2016c) reasons for this
32116 vary from legal constraints (England) to the small number of approved management plans (Romania and
32117 Slovenia) (European Commission, 2016c). In other cases Natura 2000 payments were implemented only in
32118 agricultural areas (Portugal, Spain-Aragon) or forestry areas (Germany-Mecklenburg-Vorpommern) and only in
32119 some cases (Bulgaria, Slovakia and Estonia) (European Commission, 2016c). To increase the impact of Natura
32120 2000, the lack of adoption of Natura 2000 payments in national and regional rural development plans by member
32121 States and the low enrolment by farmers needs to be addressed by a multifaceted strategy. This includes
32122 increasing awareness of the positive Natura 2000 effects among national governments and the general public,
32123 advice and training to farmers, better tailoring of the measures to the local context, improving monitoring and
32124 reporting, and studying the promotion of a result-based “biodiversity conservation premium” (see synthesis
32125 **Table 6.11**).

32126 **End of Box 6.5**

32127

32128 **Table 6.6: Main policy objectives, instruments, status and trend of delivery and key findings for selected contributions from nature to people in agricultural**
 32129 **land in Western and Central Europe**

32130 (see also Highlights in electronic Appendix 6.3)

Nature's contributions to people	Main Policy Objectives	Main Policy Instruments	State and trends of delivery of nature's contributions to people	Key Findings: Constraints	Key Findings: Opportunities
Food	long-term food security in European Union; growing global food demand; sustainable production	Regulatory e.g. cross-compliance, and greening requirements; Economic: e.g. World markets; subsidies such as farm direct payments; Social and information-based: quality product certification	Stable but at risk of dependency on imports →	Difficult traceability of some food chains (e.g. meat) Stenmark (Stenmark, Jensen, Qusted, & Moates, 2016) estimated that in 2012 in EU-28, food wastes amounted to 88 million tonnes of which 53% was attributable to households, 19% to processing, 12% to food service, 11% to production and 5% to wholesale and retail. Competition with other contributions from nature to people	Cross-compliance and greenings reference levels better defined if accounting for local ecological and agronomic requirements; Possibility to increase modulation from pillar 1 to pillar 2 Incentivize Short food supply chains Reducing industrial meat production due to its environmental impacts and large dependency on imports; Promoting extensive livestock farming and pastoralism Halting land grabbing, land degradation and sealing
Energy (Biomass-based)	European Union Directive 2009/28/EC on renewable energy (RED) sets a 20% share of energy from renewable sources to be achieved by 2020.	Regulatory: RED (art. 17, 18, 19) mandatory sustainability criteria for biofuels and bio-liquids; RED excludes land categories, with high biodiversity value, from being used for bio-fuel production; Common Agricultural Policy CC requirements; Economic: RD measures supporting production of biomass for bio-energy; Energy and CO ₂ prices	Supply not at risk ↗	Possible intensification of energy crops production with direct and indirect impacts on biodiversity and trade-off with other contributions from nature to people (e.g. food production); Emissions from transportation of biomass from sites of production to be consumed far away Competition with other contributions from nature to people	Important source of energy for remote rural areas Local production and consumption of bio-based energy is usually more sustainable than having biomass travelling long distances
Regulating Fresh Water quality	Surface water bodies to reach Good Ecological Status by 2015	Regulatory (e.g. WFD, Nitrates Directive, Common Agricultural Policy pillar 1, CC, greening); Economic: Pricing policy (Full Cost Recovery of water services)	Self-purification as a service delivery is decreasing ↘ Water quality increasing due to limitation of pollutants from policies but still at risks of insufficiency for surface water ↗	Need to further improve CC, efficiency of nitrogen use, waste water management and full compliance with the Nitrates Directive (EEA, 2015c). Need to restore riparian vegetation	Clear policy targets and territorial approaches such as, respectively, Good Ecological Status and river basin plans, allows better monitoring and feedback for amelioration of policies; Establishing green infrastructure strategy

Climate regulation	Objectives of RD linked to climate 1) Restoring, preserving, enhancing agriculture & forestry ecosystems; 2) Promoting resource efficiency and the shift towards a low carbon & climate resilient economy	<p>Regulatory e.g. CC, and greening requirements</p> <p>Economic: RD measures supporting establishing of semi-natural areas, CO₂ sequestration, promoting reduced emissions and energy use efficiency;</p> <p>Energy and CO₂ prices,</p>	<p>Sufficient in extensive agricultural land (also because of forest surface increases) →</p> <p>Not sufficient in intensive agricultural land →</p>	Use of fossil fuels, chemical inputs, and deep ploughing, intensive rearing of cattle are amongst the main factors contributing greenhouse gases emissions from agriculture	<p>Possibility for European Union member States to use some RD measures of Common Agricultural Policy pillar 2 to address climate emissions and CO₂ sequestration</p> <p>Greening conservation of grassland and ecological focus area could have some positive effects on carbon sequestration if thresholds are set at an appropriate level</p> <p>Emissions from agriculture are decreasing</p>
Pollination	to produce diversified, high-quality food while conserving natural resources and biodiversity	<p>Regulatory (e.g. Framework Directive on the sustainable use of pesticides, Common Agricultural Policy pillar 1, CC, greening);</p> <p>Economic (PES such as Agri-environmental measures for integrated pest management & organic agriculture);</p>	Insufficient delivering ↓	Too loose and general reference levels by Common Agricultural Policy CC and GR of Common Agricultural Policy pillar 1	<p>Green Infrastructure Strategy could be an innovative instrument for the conservation of habitats favourable to pollinators species but it is still under development;</p> <p>Referenced level in CC requirements should match actual IPM and agri-environmental payments should be allowed only for organic agriculture. (see also responses in Table 6.4.1 and Table 6.4.2.1, chapter 6 IPBES Pollination Assessment (S. G. Potts, Imperatriz-Fonseca, & Ngo, 2016).</p>
Habitat & Biodiversity	EU Biodiversity Strategy 2020; To halt the loss of biodiversity by 2020; Aichi Biodiversity Targets;	<p>Regulatory (e.g. habitats and species Directives; WFD; Common Agricultural Policy pillar 1 CC and Greening);</p> <p>Economic (AEM such as Natura 2000 payments)</p> <p>Social and information-based: HNMF concept</p>	Insufficient delivering ↓	<p>Too loose and general reference levels for supplying also public goods by CC and GR of Common Agricultural Policy</p> <p>Insufficient funding of instruments targeted to habitat & biodiversity,</p> <p>Insufficient political commitment at national and local levels;</p> <p>Severe under-funding of Natura 2000 areas and HNMF by insufficient implementation of locally relevant AEM;</p> <p>Insufficient advisory services for farm biodiversity management</p>	<p>CC and GR tailored on agro-ecosystem typologies;</p> <p>Increasing advisory services for farm biodiversity management;</p> <p>Establishing green infrastructure strategy</p> <p>Enforcing the delivering of management plans for biodiversity conservation in order to receive compensations;</p> <p>Design of local result-oriented AEM,</p> <p>Adequate compensation to the income forgone (and to ecological added value);</p>
Physical & Psychological experience	Not identified	<p>Economic (e.g. Rural tourism demand; AEM on encouragement of tourism activities); social and information-based (e.g. some LEADER initiatives)</p> <p>Social and information-based: HNMF concept, farmers' indigenous and local knowledge</p>	<p>Increasing in traditional agricultural landscape ↗</p> <p>Insufficient in areas of agriculture intensification</p>	<p>Missing thoroughly official statistics data on rural tourism at European Union level;</p> <p>Risk of tourism congestion in some areas and absence in others</p> <p>Competition with other contributions from nature to people</p>	<p>Increasing offer and demand for recreational activities and rural tourism;</p> <p>The private character of rural tourism business is linked to the delivering of other public goods such as maintenance of traditional landscapes and cultural heritage;</p>
Heritage	Protection, management & planning of landscape in	<p>Regulatory (e.g., national laws);</p> <p>Economic (e.g. AEM on Conservation of rural heritage);</p>	Increasing awareness but still insufficient in intensive agricultural areas ↗	<p>Homogenization of culture and tastes;</p> <p>Costs of maintenance of traditional rural infrastructure;</p>	Understanding motivations of farmers managing HNMF;

Europe (Council of Europe, 2000)	social and information-based (e.g. geographical indications, some LEADER initiatives)	Insufficient maintenance of indigenous and local knowledge→	Difficulties on making HNMF concept operational because of lack of data and different methodologies used to identify HNMF (Beaufoy & Cooper, 2009; EEA, 2012b; Keenleyside, Beaufoy, et al., 2014);	Societal recognition of the importance of farmers managing HNMF;
Directive 2006/144/EC lists conservation and development of HNMF as a priority for RD 2007/2013	Social and information-based: labelling, HNMF concept, farmers' indigenous and local knowledge		Low profitability of HNMF	Increasing solidarity between farmers and the public;
			Difficulties in accessing Common Agricultural Policy payments by small farms in HNMF	Developing short food supply chains (e.g. Quality product market niches, On-Farm direct selling, Farmer markets, delivering box schemes, e-commerce);
				Establishing a European Union labelling for agricultural products from HNMF and Natura 2000 areas

32131 Legend

Trend of nature's contributions to people delivering	State of nature's contributions to people delivering at the end of the period	Abbreviations
↑= strongly increasing ↗= increasing →=stable ↘= decreasing ↓=strongly decreasing	Oversupply Delivering at risk of oversupply Supply not at risk Delivering at risk of insufficiency Insufficient delivering	RD = Rural Development CC = Cross Compliance GR = Greening Requirements AEM = Agro-Environmental Measures HNMF = High Nature Value Farmland

32132
32133

32134 6.5.1.4 Agriculture context in Eastern Europe and Central Asia

32135 The agricultural sector is crucial for the economic development of Eastern Europe. As the region
 32136 benefits from a mild climate and highly productive agricultural soil, it can contribute to meeting the
 32137 increasing global demand for food in the future. Water resources and developed irrigation systems are
 32138 other important assets of the subregion's agricultural sector (OECD, 2011). Radical land reform
 32139 implemented after the dissolution of the Soviet Union in 1991 has strongly affected agriculture in the
 32140 region in the 1990s. Agricultural land was divided into small plots and distributed among former farms'
 32141 members and employees. However, large areas of land such as pastures and reserve lands remained
 32142 in public ownership. In Georgia, Azerbaijan and Armenia, the agricultural sector is represented largely
 32143 by small rural households whose main agricultural activities include animal husbandry, grazing in high
 32144 mountain pastures, and cultivation of plateaus. Small farms produce mostly for subsistence
 32145 consumption with a small surplus being sold at local markets (about 95% of agricultural products in
 32146 Georgia and Azerbaijan, and 97% in Armenia). Conversely, in Russia, Belarus and Ukraine the sector is
 32147 dominated by large agro-enterprises producing grains and oilseeds for export (FAO, 2012).

32148 Privatization reforms in Eastern Europe were initiated with the objective of facilitating fast
 32149 development of land markets, economies of scale and farm management. However, this did not
 32150 happen in the majority of countries. Instead, the reforms shifted the sector to less intensive
 32151 agricultural production and decreased productivity, which has generally benefited the environment
 32152 (FAO, 2012). (Prishchepov, Radeloff, Baumann, Kuemmerle, & Müller, 2012) report that institutional
 32153 change in many post-Soviet countries led to agricultural land abandonment and that many abandoned
 32154 agricultural fields are slowly reverting to grassland and forest. This may have major implications for
 32155 biodiversity. For example, land abandonment may increase landscape heterogeneity and biodiversity
 32156 of bird population.

32157 There are, however, indications that the economies of transition countries are starting to grow, and
 32158 pressure on natural resources will increase again, again with major implications for biodiversity and
 32159 ecosystem services (Sutton et al., 2008). The challenge faced today is how to encourage the
 32160 development of more sustainable production systems and the provision of ecosystem services. Failure
 32161 to do so has serious economic, environmental and social costs. For example, in Moldova, soil erosion
 32162 is estimated to cost at least \$40 million per year; in Ukraine about 50% of agricultural land is eroded;
 32163 and contamination of water by agricultural nutrients and pesticides is of great concern across the
 32164 subregion.

32165 Similar to Eastern Europe, Central Asian countries (**Box 6.6**) experienced the Soviet regime and are
 32166 facing rapid transformation processes since independence in 1991, thereby gaining valuable
 32167 experience in designing institutions in natural resource management that had to be adapted to the
 32168 specific natural conditions and agricultural practices of the subregion. The agricultural sector is of
 32169 fundamental importance in the subregion's economies. The use of 399.4 million hectares of
 32170 agricultural land is constrained, however, by biophysical factors of arid and continental climate. Most
 32171 of the territory of Central Asia is covered by deserts, steppes and mountains. Winters are extremely
 32172 cold and summers hot and dry, and precipitation relatively low (up to 150mm in deserts of
 32173 Turkmenistan and Uzbekistan, up to 400mm in Kazakhstan's steps and up to 800mm in the mountain
 32174 areas of Kyrgyzstan and Tajikistan). Due to climatic and topographic conditions, grassland is a dominant
 32175 type of land here with only 8% of arable and 4% forest land (**Figure 6.8**).

32176 **Box 6.6: Agriculture in Central Asian countries (Quillérou et al., 2016)**

32177 In **Kyrgyzstan**, seasonal migratory grazing was historically the main type of livestock management. However,
 32178 more accessible spring/autumn pastures now used during all seasons. As a result, they are overgrazed, requiring
 32179 improvement of their management.

32180 In **Tajikistan**, most economic and livelihood activities of the country’s population take place in the foothills and
32181 low mountains where the country has largest type of pastures (by size).

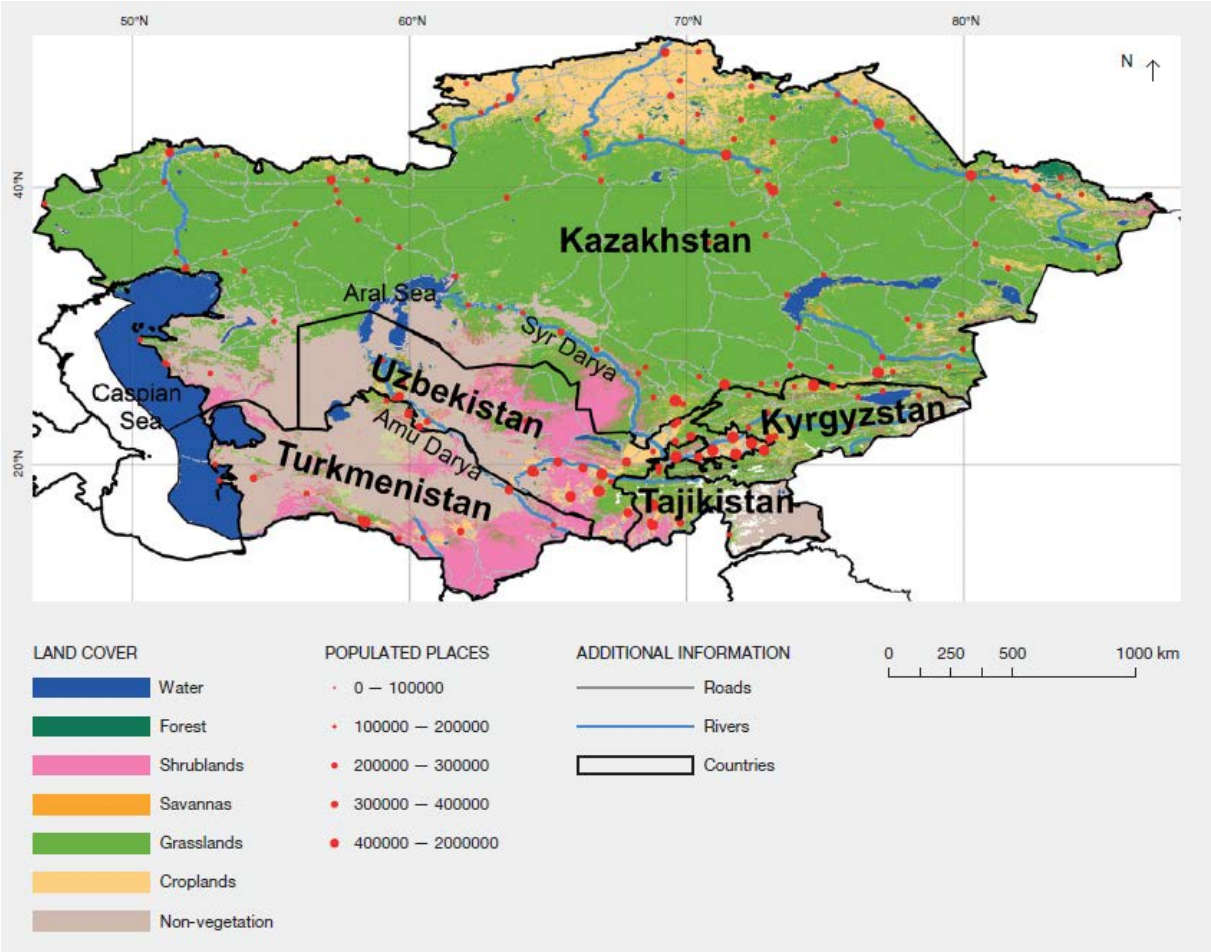
32182 In **Turkmenistan**, lowland pastures provide around 60% of the economic value of ecosystem services to
32183 traditional rural communities.

32184 **Uzbekistan** consumes the largest share of available water in the region to irrigate the largest area of land, which
32185 contributes 20-30% of the country’s GDP.

32186 **Kazakhstan** has the second largest area of irrigated land. Moreover, about 80% of pastures depend on manmade
32187 facilities using subsurface water.

32188 **End of Box 6.6**

32189 Small and medium-sized family farms established in Central Asian countries during the last decade play
32190 a crucial role in agriculture today. Their share of gross agricultural output is between 71% (Kazakhstan)
32191 and 98% (Uzbekistan) (K. Schroeder, 2016). However, the opposite trend has also been observed
32192 recently, i.e. the accumulation of land by large agro-holding companies in Kazakhstan, and an increase
32193 in farm size in Uzbekistan as a result of the governmental policy of “land optimization”. Although land
32194 is leased to farmers for up to 49 years in Uzbekistan, they may lose their land if they do not execute
32195 state orders for producing cotton and wheat (K. Schroeder, 2016).



32196
32197 **Figure 6.8: Land cover map of Central Asia. Source: (Zhou et al., 2015).**

32198 High unemployment in Kyrgyzstan, Tajikistan and Uzbekistan contributes to poverty, which has
32199 become a serious problem in these countries (**Table 6.7**). Although as Soviet republics they were
32200 already the poorest of the USSR (in particular Kyrgyzstan and Tajikistan), the situation has substantially
32201 worsened over the last decade. This is especially the case for rural populations living in areas where

fertile land and water are scarce, and where deterioration of these resources is a serious problem. Extensive degradation is observed in the region with estimates that 4-5% of cropped land, 27-68% of pastures and 1-8% of forest land, are degraded (Quillérou et al., 2016). As a result, migration from rural areas is increasing. The majority of migrants move to cities and neighbouring countries such as Kazakhstan and Russia. According to Schroeder (K. Schroeder, 2016), about 4.5 million migrants from Kyrgyzstan, Tajikistan and Uzbekistan live and work in Russia.

Table 6.7: Population wealth and livelihood indicators in Central Asian countries. Source: (International Monetary Fund, 2015; World Bank, 2015); (UN DESA, 2015), cited in (K. Schroeder, 2016).

	Population (mln.)	Average population growth (annual %)	Per capita GDP (USD)	Average GDP growth (annual %)	Unemploy- ment rate (%)	Agriculture value-added (% of GDP)
	2014	2010-2014	2014	2010-2014	2014	2014
World	7 259.7	1.19	10 739	2.5	5.9	3.1
Kazakhstan	17.3	1.4	12 276	6.0	4.1	4.6
Kyrgyzstan	5.8	1.6	1 269	3.7	8.1	17.3
Tajikistan	8.3	2.3	1 114	7.1	10.1	27.4
Turkmenistan	5.3	1.3	9 032	11.0	10.5	14.5
Uzbekistan	30.7	2.0	2 038	8.2	10.6	18.8

6.5.1.5 Transformation of environmental governance in Eastern Europe and Central Asia

In Eastern Europe and Central Asia, the importance of environmental protection is usually recognized in the statements of agricultural policies, but countries often struggle to implement these. An illustrative example of this is the soil protection institutions in Ukraine. Stupak (Stupak, 2016, p. 86) argues “that having destroyed the elaborate Soviet soil protection system, Ukraine did not manage to develop a new set of legal rules, nor their enforcement mechanisms, to enable soil protection in the new political and economic setting”. During the last decade of post-socialist transition, agricultural policies in the subregion have been dominated by privatization reforms implemented with strong technical and financial backstopping from international donors. The World Bank and the International Monetary Fund conceptually and financially supported the design and implementation of the transition reforms for all post-Soviet countries. The objective of these purely economic policy-based prescriptions, known as the “Washington Consensus”, consisted of four policy interventions: price liberalization, stabilization, privatization and minimization of the state role. The reforms had a powerful impact on the management of natural resources and shifted the governance modes away from hierarchical centralized governance. The situation varies from country to country, but it seems that the new modes of governance (decentralized, public-private partnerships and private governance) are still under development and the mismatch between the hierarchical governance structures and the new decentralized institutions persists in many post-socialist countries (Klůvanková-Oravská et al., 2009).

The literature reports a land-grabbing problem in post-Soviet Eurasia (Visser & Spoor, 2011). This is particularly relevant for Russia, Ukraine and Kazakhstan where large domestic and foreign state and private companies acquire vast areas of farmland. Deininger & Byerlee (Deininger & Byerlee, 2011 p. 88) warn: “If property rights are secure, markets function well, and areas with high social or

environmental value are protected effectively (possibly using market mechanisms, such as payments for environmental services) the public sector's role is mainly regulatory. The public sector takes care of environmental externalities and allows markets, including those for land, to function smoothly and to encourage expansion into low grade pastures and degraded forest rather than into areas already occupied or with high biodiversity value. But if land rights are insecure or ill-defined, large-scale land acquisition may threaten forest or lead to conflict with existing land users". The large-scale land acquisitions in these countries might well have far-reaching consequences for the livelihoods of the rural population, nature's contributions to people and biodiversity.

Since the dissolution of the Soviet Union in 1991, independent Eastern European and Central Asian countries have implemented reforms and policies transforming environmental governance. Many natural resource management systems such as irrigation, forest, and pasture organizations were highly centralized and had to undergo fundamental transformation.

In Central Asia, decentralization policies were introduced with the objective of promoting the more sustainable use of natural resources. Countries received strong financial and logistic support from international donor agencies. For instance, Kyrgyzstan implements devolution of power and decentralization of authority in pasture management to the newly created political level of "local self-governance" and "pasture user unions and pasture committees" (**Box 6.7**). Other Central Asian countries are currently considering following this example by introducing new regulations with individual or common forms of tenure (Robinson, Wiedemann, Michel, Zhumabayev, & Singh, 2012).

With regard to irrigation water, Central Asian countries have transferred authority for management to non-commercial voluntary organizations of water users that finance themselves through members' payments for water service delivery. They are responsible for operating, maintaining and rehabilitating the irrigation system, delivering water to end users, purchasing water from the state, and collecting water fees from users (Herrfahrdt et al., 2006; Ul Hassan, Starkloff, & Nizamedinkhodjaeva, 2004); (Sehring, 2007 cited in) (Bichsel et al., 2010).

This represents a fundamental change in the relationship between state, market and civil society with regard to pasture and irrigation water management, by moving away from the hierarchical top-down governance and command and control policy instruments, inherited from the Soviet past (**Box 6.7**).

6.5.1.6 Assessment of environmental governance in Eastern Europe and Central Asia

Despite the challenges in transforming environmental governance in Eastern Europe and Central Asia, there are several positive trends reported in the literature (Sutton et al., 2008). For instance, the latest agricultural strategies incorporate or integrate environmental targets including their evaluation, while inter-ministerial cooperation is improving in most countries (see synthesis **Table 6.11**). Moreover, agricultural and research systems are increasingly addressing environmental and sustainability issues.

However, other important policy instruments such as awareness and capacity building of farmers are generally inadequate (see synthesis **Table 6.11**). The non-existence of advisory and extension services may contribute to the problem. The previous system of top-down directives to collective and state farms is no longer relevant and has to be replaced, but only a few countries have experimented with innovative and low-cost alternatives. Other problematic issues to be addressed include: the need to strengthen monitoring systems, lack of programmes addressing widespread erosion problems; weak certification policies and nutrient management; and lack of strategies to promote organic farming and certification (see synthesis **Table 6.11**) (Sutton et al., 2008).

The Central Asian experience of the decentralization of environmental governance offers valuable insights. Based on the design and implementation of irrigation water management reforms, it can be

observed that, despite the introduction of different agricultural policies and formal institutions, the problems remained similar. This includes weak, newly established institutions; poor public acceptance and lack of legitimization of new regulations and governance structures among resource users; and the growing gap between the implemented policies and the users' resource use and management practices (Hamidov, 2015; Sehring, 2007). This is very much true for the pasture sector (**Box 6.7**). A brief review of the literature presented here offers some important insights regarding constraints faced by policymakers and resource users in both key sectors.

The life and scope of action of resource users and policymakers in Central Asia are profoundly affected by multiple historic turning points, each characterized by a radical change of systems and ideologies. Transformation in natural resource use and management in Central Asia has been shaped not only by its Soviet past, but also its colonial past (Schmidt, 2013). Decentralization policies are largely build on the longstanding misconception of traditional institutions (Jacquesson, 2010). For instance, agro-pastoral communities in Central Asia are often perceived as homogenous, which they no longer are. Increasingly, rural communities are characterized by striking power asymmetries (Kerven, Steimann, Ashley, Dear, & Ur-Rahim, 2011; Steimann, 2011). Furthermore, the role of bargaining power is underestimated in policymakers' societal perceptions, beliefs and formal institutions, but it plays a huge role in access to the resource itself and the creation of informal rules among resource users. The ability of policy interventions to reduce power asymmetries is decisive in changing informal rules and resource use and management practices (Kasymov, 2016).

Box 6.7: Shifting governance arrangements and policy reforms in Central Asia: The case of pasture management in Kyrgyzstan

Pasture land is a key natural resource in Kyrgyzstan (**Figure 6.9**). There is strong consensus among scholars today that sustainable pasture use and management in Central Asia depends largely on pastoral migration (**Figure 6.10**). However, the early post-Soviet pasture management reforms in Kyrgyzstan did not recognize the importance of institutions coordinating pastoral migration and did not take into account the economic and political dynamics related to mobile herding (Dörre, 2012; Jacquesson, 2010; Steimann, 2011; Undeland, 2005). As a result, a massive reduction in pastoral mobility was observed after implementation of those early reforms (1991-2009). Reduced mobility led to the overgrazing of pastures, decreasing livestock productivity and increasing conflicts between pasture users over access to the resource (Farrington, 2005; Ludi, 2003; Undeland, 2005; Wright, Malmakov, & Vidon, 2003). In Kyrgyzstan, overgrazing causing soil and land degradation is also perceived as the key pressure and driver of changes in biodiversity and ecosystem services. For instance, the National Report on Conservation of Biodiversity states that pressure on more than 3,500 species, which grow on pastures, increases due to overgrazing (Kyrgyz Republic, 2013).

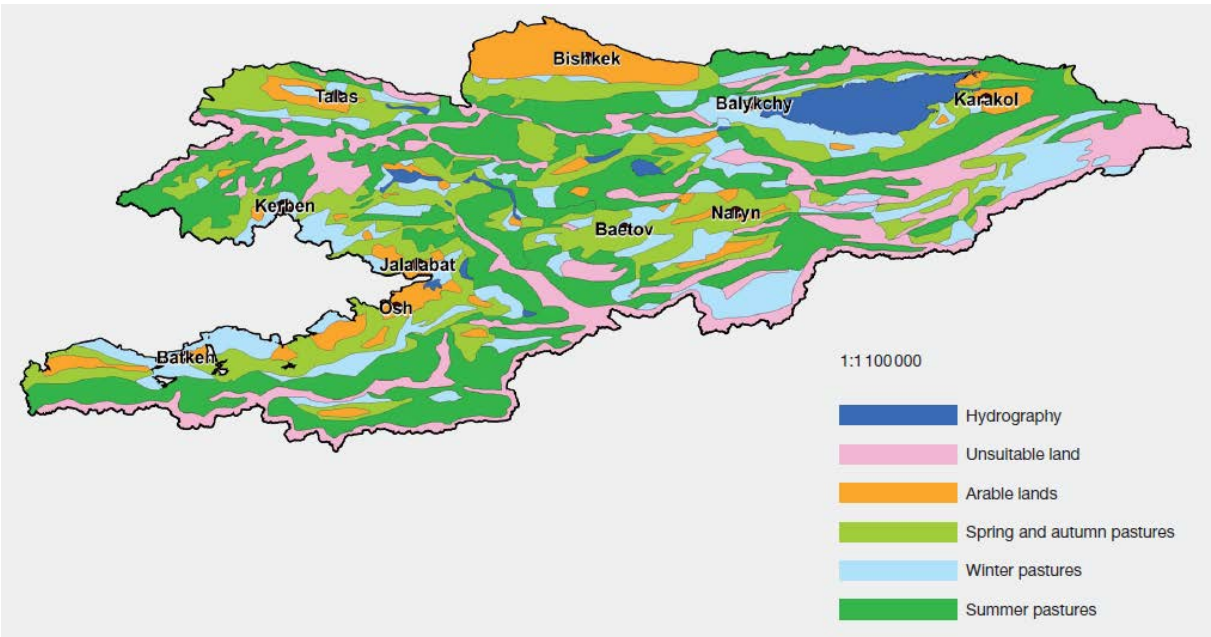


Figure 6.9: Pastures in Kyrgyzstan. Source: Adapted from Penkina (Penkina, 2004)



Figure 6.10: Herders on summer pastures in Kyrgyzstan. Source: Photo by Ulan Kasymov.

Responding to pasture-related problems the Kyrgyz parliament adopted a new law “on pasture” in January 2009 (Kyrgyz Republic, 2009). With the objective of promoting more sustainable use of pastures, the new law introduced radical changes to the pasture management system: (1) it abolished the three-level Soviet-era system of state pasture management based on spatial pasture characteristics – transferring the responsibility for pasture management substantially to the local level and placing it on municipalities and the newly formed pasture user

unions and pasture committees; (2) it abolished the area-based long-term pasture lease system and introduced an annual livestock-based pasture fee (“pasture ticket”); and, lastly, (3) it introduced a planning and monitoring system for pasture use and management. By 2011, Pasture user unions and pasture committees had been created in 454 municipalities in Kyrgyzstan (World Bank, 2011).

The shift in governance is a fundamental change of roles and positions between state, market and civil society with regard to use and management of pastures and is an attempt to move away from the hierarchical top-down governance, inherited from the Soviet period, to a hybrid one – a mix between the “decentralized”, “self-governance” and “private governance” modes. As a result, considerable changes of actors and institutional features have occurred in Kyrgyzstan (Table 6.8).

Table 6.8: Governance modes in pasture management in Kyrgyzstan. Source: Own representation.

	Hierarchical governance before 1991	Decentralized (since 1995)	Public-private governance (since 2009)	Self-governance (since 1991)
Actors	Department of Pasture at the Ministry of Agriculture at national level Departments of pasture at the regional and district levels	Department of pasture at the Ministry of Agriculture at national level Departments of pasture at the regional and district levels Municipalities	Municipalities, Pasture User Unions and Pasture Committees	Pasture users (e.g., herders and livestock owners)
Power	Coercion	Coercion	Competiveness	Autonomy of pasture users Informal leaders Social capital and trust
Representation	Pluralist ((supra) national elections)	Pluralist (local elections)	Partnerships Arrangements between Pasture Committees and pasture users	Partnerships Participatory private-private governing arrangements (e.g., informal herding arrangements)
Mechanism of social interaction	Top-down; command and control	Municipalities decide autonomously on pastures within their boundaries	Pasture Committees develop and enforce the implementation of the pasture management plans in a participatory process	Bottom up; social learning, deliberation and negotiation regarding access to and use of the resource

Since 1991, new key actors have emerged, changing the configuration of stakeholders: (a) after the dissolution of state farms and privatization of livestock, private livestock owners and herders became *de facto* managers of pastures; (b) municipalities within the borders of former collective/state farms were created during the decentralization reform; and (c) pasture committees and pasture user unions were established within the latest pasture legislation. Power relations among those stakeholders has also changed significantly. Initially, the main responsibility for managing pastures within the municipality borders was delegated from the national and regional levels to the municipal level. Later, this responsibility was shifted again to the newly established pasture committees and pasture-user unions. Furthermore, “representation” has changed from “pluralistic” at the national and regional level to a mix between the “pluralistic” and “corporatist” at the local level, when pasture-use agreements are to be negotiated between pasture committees and pasture users. Finally, the “mechanism of social interaction” has been transformed from “top down” and “command and control” to a less formal and more interactive one.

An important feature of the latest pasture reform is that a mix of policy instruments was developed just after the legislation was approved by the parliament in 2009, and tested while the reform was implemented (Table 6.9). One of the first tasks for each newly established Pasture Committee is the collection of *pasture fees* and

the allocation of *pasture tickets* to pasture users. The collected pasture fees finance the committee's overhead costs and are invested in pasture infrastructures and improvement. The pasture fee is defined annually by the pasture committee for each type of livestock as well as for each type of pasture. It cannot be lower than the basic tax for using a pasture, and it needs to be approved by the respective municipality. The collection of pasture fees is, however, a difficult task, since livestock monitoring is a problem in many communities. The pasture ticket is allocated according to annual pasture use and a management plan, which is developed and implemented under the coordination of the responsible Pasture Committee. The capacity and condition of pastures (productivity and level of degradation) and the size of livestock populations needs to be monitored and assessed annually by pasture committees as a basis for negotiations concerning the allocation of pastures for the following year's pasture use plan.

Table 6.9: Policy instruments in pasture management in Kyrgyzstan since 2009. Source: Own representation.

Legal and regulatory instruments	Economic and financial instruments	Social and information-based instruments	Rights-based instruments and customary norms
Pasture Law (2009) Pasture use and management planning Pasture use monitoring	Pasture fee and land tax Grants to Pasture Committees and Pasture Unions	Information regarding pastures (e.g., distribution, state) Awareness building and trainings organized by NGOs and extension services	Pasture collective rights Customary norms and institutions

The literature is divided in assessing the effectiveness of the more recent pasture reform in Kyrgyzstan (implemented since 2009): to what extent did the policy intervention contribute to achieving a more sustainable use of pastures as the main policy objective? Critical assessments of the reform's impact are offered by Crewett (Crewett, 2015) and Dörre (Dörre, 2015). While Crewett investigates how policy implementers at the local level ("street-level bureaucrats") simplify information rules in the donor-initiated natural resource governance reforms at the expense of a more participatory resource user involvement, Dörre (2015, p. 1) compares "promises" of Kyrgyzstan's pasture-related legislation and "realities" of its implementation. In his opinion, *"the recent innovation in pasture law has not comprehensively resulted in the desired outcomes on the ground"*. Furthermore, (Ridder, Isakov, & Kasymov, 2017) evaluate the costs and instrumental benefits of different land-use strategies with regard to pasture degradation. The study comparatively assesses alternative pasture management strategies, reflecting on their impact on pasture and livestock productivity. The authors conclude that allowing pastures to rest will lead to higher net benefits and would be a more beneficial choice for herders economically. However, awareness about the relationship between overgrazing and pasture or livestock productivity has not been translated into action by pasture users due to the lack of consensus between experts and herders regarding which interventions are needed and how they should be organized (Ridder et al., 2017). Kasymov (Kasymov, 2016 p. 7) argues, on the other hand, that enforcement of new formal institutions in pasture use and management affects the relative bargaining power and distributional advantage of actors. Thus, it has a redistributive character in supporting less powerful actors and contributing to the selection of more socially-optimal strategies adopted by pasture users. All authors agree, however, that the latest reform in pasture management in Kyrgyzstan is still a "work in progress" and a longer-term perspective as well as more research will be required to evaluate the environmental and social impacts.

End of Box 6.7

Governance of natural resources and biodiversity requires compatibility between ecological and social systems (Paavola & Adger, 2005) and implies that institutions coordinate complex interactions between people and nature, maintaining the ability of the ecological system to support the social and

economic systems (Hodgson, 2004). To address the problems listed above, Eastern European and Central Asian countries may need to transform environmental governance, redefining the role of state and civil society, their power, and mechanisms of interactions in natural resource management.

Several aspects need to be considered when designing policy interventions in Eastern Europe and Central Asia. First, for the countries rich in land resources, such as Russia, Ukraine and Kazakhstan, an important governance challenge is to address land grabbing and the potential exploitation of existing institutional weaknesses by powerful investors (see also synthesis **Table 6.11**). Second, the governing dynamics of land abandonment observed during the initial transition period, and recent intensification of land use, will be crucial for protecting environmental services and biodiversity in the regions. Finally, Central Asian experiences in decentralization and devolution illustrate that the process of institutional change is not straightforward but rather, complex and dynamic. As institutions are designed to coordinate complex interactions between ecological and social systems, which is characterized by processes of evaluation and co-evolution, institutional development is also very much a result of co-adaptation and learning. Therefore, institutional design to protect biodiversity and environmental services must strengthen and build upon local knowledge, practices and agricultural institutions (synthesis **Table 6.11**).

6.5.1.7 Summary

In recent decades, the governance of the agricultural sector has undergone important changes in Europe and Central Asia.

In Western and Central Europe, the establishment of the European Union Common Agricultural Policy saw at first strong support for production by government intervention, which led to unsustainable negative impacts on the economic, socio-cultural and environmental systems. Then, from the 1980s, Common Agricultural Policy reforms promoted the decoupling of farm income support from production, the reduction of agricultural surplus, the control of budget costs and the integration of socio-cultural and environmental objectives into the policy. Various policy instruments from different instrument categories were used to achieve these objectives, such as relevant environmental regulations and laws, rural development plans, agri-environmental measures, food quality labelling, participatory processes involving stakeholders, and the adaptation to market conditions by farms. While the Common Agricultural Policy budget spent on production of agricultural commodities was reduced and agricultural pressures on the environment lessened, significant progress is still lacking in enhancing the delivery by the agricultural sector of some of nature's contributions to people that are public goods such as air, water, and climate regulation, soil erosion and water run-off control, conservation of habitats and biodiversity, and maintenance of traditional culture and agricultural landscapes. The delivery of nature's contributions to people may be supported by the agricultural sector if Common Agricultural policy objectives are defined more clearly (e.g. what are farm income and environmental objectives supported in the policy's pillar 1) (see also synthesis **Table 6.11**) and policy instruments are made more efficient and effective. This could be achieved, for example, by fine tuning Common Agricultural policy cross-compliance and greening requirements to critical ecological thresholds for nature's contributions to people delivery by agro-ecosystems at local level in pillar 1 and by developing more effective and more result-oriented agri-environmental measures tailored to local conditions in pillar 2 (see synthesis **Table 6.11**).

In Eastern Europe and Central Asia, the dissolution of the Soviet Union in the 1990s led to a decentralization of governance of the agricultural sector and to privatization and redistribution of land to farmers. This has, in many countries, resulted in a reduction of big state farms in favour of small to medium-sized private farms producing for subsistence consumption and local markets. It also resulted

in the establishment of large agro-enterprises producing grains and oilseeds for exports in Russia, Belarus and Ukraine in Eastern Europe and Kazakhstan in Central Asia, and big farms as a result of “land optimization” governmental policy in Uzbekistan. The results of these land reforms, from an environmental point of view, have been less intensive agricultural production, a decrease in productivity in small- to medium-size farms, and land abandonment that have generally benefited the environment. However, the transition toward a market economy is already showing signs of increasing intensification of agricultural practices leading to big environmental impacts (e.g. soil erosion in Moldova), high unemployment rates in rural areas (e.g. in Kyrgyzstan, Tajikistan and Uzbekistan), and land-grabbing problems in post-Soviet Eurasia (e.g. Russia, Ukraine and Kazakhstan). Since the dissolution of the Soviet Union in 1991, in independent Central Asian countries many natural resource management systems such as irrigation, forest, and pasture organizations have transferred authority to local stakeholders (e.g. pasture user unions and pasture committees in Kyrgyzstan, non-commercial voluntary organizations of water users for irrigation of water). This represents a fundamental change in the relationship between state, market and civil society with regard to pasture and irrigation water management, by moving away from the hierarchical top-down governance and command-and-control policy instruments, inherited from the Soviet past

Despite these positive trends, such as the integration and evaluation of environmental targets, inter-ministerial cooperation, and improved research systems (see also synthesis **Table 6.11**) there are many pitfalls. These include the lack of awareness and capacity building of farmers, non-existence of advisory and extension services, weakness of newly established institutions, poor public acceptance and lack of legitimization of new regulations and governance structures among resource users, and the growing gap between the implemented policies and actual management practices (see also synthesis **Table 6.11**). To address these problems, there is a need to transform environmental governance by redefining the role of state and civil society, their power, and mechanisms of interactions in natural resource management (see also synthesis **Table 6.11**). To enhance nature’s contributions to people and biodiversity conservation in the regions, new governance systems will also have to address the problem of land grabbing and the potential exploitation of existing institutional weaknesses by powerful investors (e.g. in Russia, Ukraine and Kazakhstan). Governance systems will also have to address the abandonment of land and the recent intensification of land use by securing property rights and responsibilities, as well as designing and enforcing legal standards to sustain biodiversity and nature’s contributions to people (see synthesis **Table 6.11**).

6.5.2 Forestry

6.5.2.1 Policy objectives

Forests and other wooded land cover about 1,172 million ha in Europe and Central Asia. Since 2000 there has been a net increase of forest in nearly all countries due to afforestation policies and natural expansion on, for example, abandoned agricultural land (see Chapter 4) (UNECE/FAO, 2015). The forest area is heterogeneously distributed across the region (UNECE/FAO, 2015). The Russian Federation has by far the most, with 890 million hectares, which represent 54% of its total land area. This is far above the average proportion for other Eastern European countries (approximately 40%), as well as Western Europe (about 35%), and Central Asia (< 10%). The economic significance of forestry varies between countries of the region. Based on the current system of national accounts (see Section 6.6.3), the contribution of the forestry sector to the overall Gross Domestic Product is below 1% on average, except for several eastern and northern European countries, such as Latvia (6.5%), Estonia (4.3%), Finland (4.3%), Sweden (2.9%), Slovakia (2.4%), Lithuania (2.4%), Romania (1.9%), Slovenia (1.8%). In addition to the variation in biophysical and socio-economic factors, there is a large variation in forest

property rights within Europe and Central Asia. Private ownership of forest land ranges from about 40 to 80% in the northern and north-western European countries and from 10 to 60% in Eastern Europe. Small-scale land holding (up to 5ha) makes up about 85% of all forest owners in surveyed countries in Western and Central Europe (Schmithüsen & Hirsch, 2010). In Central Asia, almost all forests are publicly owned, mainly by the central government (Romano, Buttoud-Kouplevatskaya, & Reeb, 2010). User or access rights, e.g. for the purpose of recreation or berry and mushroom picking, as well as usufruct rights for indigenous peoples and local communities, also exist in some countries in Europe and Central Asia. These factors have shaped the forest policies and forest acts of individual countries in this region towards either a more production or a more post-production orientation (Arts, 2014; Forest Europe, 2015). The goal of these policies is often a multifunctional forest, including the mainstreaming of biodiversity and nature's contributions to people (see Chapter 4 Section 4.5.3). They include both managed and "near-natural" landscape elements and frequently aim – besides timber production – at providing ecological functions and recreation opportunities (Hunziker, von Lindern, Bauer, & Frick, 2012). In Forest Europe member countries, more than 30 million hectares of forests have been protected for the main purpose of conserving biodiversity, habitats or landscapes (see Chapter 4, Section 4.5.3). Over 110 million ha of forests are designated to protect water, soil and ecosystems as well as infrastructures. In mountainous regions, larger forest areas are designated for natural hazard control (see Chapter 2, Section 2.2.1.8). A majority of countries name soil protection as one of the main policy objectives, while about 30 percent indicate water protection as a priority (Forest Europe, 2015). However, this does not correspond to the policy goals set in various international and national policies. Biodiversity is still deteriorating in many countries. There are, however, many opportunities to improve the situation to achieve overarching policy objectives for the conservation of forest land, and to mainstream biodiversity and nature's contributions to people into forest policy (see synthesis **Table 6.11**).

One such opportunity would be to develop international forest policy to ensure both the conservation of biodiversity and the mainstreaming of biodiversity and nature's contributions to people at multiple levels. Almost all European and Central Asian countries are currently participating in one or more of the international or European processes towards the establishment of criteria and indicators for sustainable forest management (e.g., "Forest Europe", the "Montreal process" and the "Near East Process"). However, the internationalization of forest policy poses substantial challenges for actors in the policy process (Werland, 2009). Several forest-related instruments are applied in parallel, and processes take place simultaneously at different governance levels, which can be distinguished into relatively "hard" legal instruments (e.g., United Nations Framework Convention on Climate Change, Convention on Biological Diversity, General Agreement on Tariffs and Trade), "soft" international laws (e.g., United Nations Conference on Environment and Development Forest Principles, Agenda 21, United Nations Forum on Forests), and "private" international laws (e.g., Forest Stewardship Council, Programme for the Endorsement of Forest Certification) (Giessen, 2013). In other areas soft laws (defined as non-binding), through "*carefully negotiated and drafted statements*" (Birnie, Boyle, & Redgwell, 2009, p. 34), have been transformed into binding treaties, such as international environmental, bioethics or human rights law. In the forest sector the emerging mixed policy regime has been characterized as fragmented, ineffective and failed (Giessen, 2013), mainly due to the failure to agree on legally-binding commitments, the existence of multiple policy arenas and actors, and the change of guiding principles over time (Singer & Giessen, 2017). Major drivers of fragmentation of the international forest regime can be found in the international as well as in the domestic realm (Giessen, 2013). The main reasons for this fragmentation have been identified as institutional competition, inconsistent targets and differing sectoral interests, as well as the simultaneous application of different policy instruments (e.g. hierarchical regulation and financial incentives or "soft" measures, such as discursive or informative approaches) (Sotirov et al., 2015). Hence, (Winkel & Sotirov, 2016, p. 496)

32528 define the current situation in terms of a “*policy (dis)integration paradox*”, since little policy integration
 32529 at multiple levels has been achieved, although several initiatives are in place recognizing the need to
 32530 develop an international forest policy.

32531 Although there are many opportunities to develop policies to take forests and forestry into
 32532 consideration, a similar situation can be found at the European Union-level since there is no explicit
 32533 forest policy mandate at this level. This can primarily be explained due to the principle of subsidiarity,
 32534 variations in the management of forests and the responsibility of conducting negotiations (Edwards &
 32535 Kleinschmit, 2013). In the European Union, forest issues are seen as appendices to the agricultural,
 32536 energy, or environmental sector (Söderberg & Eckerberg, 2013). The European Union’s biodiversity
 32537 policy, in particular Natura 2000, is for example supposed to have a major impact on the protection of
 32538 forest land at the national level (Forest Europe, 2015). However, relatively little information is available
 32539 concerning the formal and financial implementation of the policy in the national forest sector (Winkel
 32540 et al., 2015). This is partly because decisions concerning the national allocation of European Union
 32541 forest funding are increasingly taken by the domestic governments according to their priorities (Kati
 32542 et al., 2014; Sotirov et al., 2015).

32543

32544 *6.5.2.2 Governance modes and policy instruments*

32545 Governance modes in the forest sector vary depending on the share of private and public forest land
 32546 in different countries. In countries with a large share of public forest land, the forest sector is often
 32547 governed through traditional hierarchical governance modes, while in countries with a large share of
 32548 private forest owners, various forms of decentralized partnerships or even private governance are
 32549 more common (Beland Lindahl, Sandström, & Sténs, 2017).

32550 New governance systems are evolving in the forestry sector aiming to secure sustainability of timber
 32551 production and forest ecosystems through the mainstreaming of biodiversity and nature’s
 32552 contributions to people. Whether these emerging systems lead to a simultaneous retreat of the state
 32553 and a reduction in governmental control is subject to debate (Arts, 2014). A possible relocation of
 32554 political power could take three different directions: upward to the international level as mentioned
 32555 above, downward to the sub-national level, and outward to private and semi-public levels (Pierre &
 32556 Peters, 2000). However, there are still substantial challenges, especially in Eastern Europe and Central
 32557 Asia, in developing integrated environmental governance systems, including the adaptation of
 32558 regulations and the enhancement of education measures in the forest sector (Carter et al., 2010;
 32559 Djanibekov et al., 2015; Křenová & Kindlmann, 2015) (see also synthesis **Table 6.11**). New international
 32560 tools and financial incentives could trigger such changes. However, a strong “ideological and
 32561 institutional anchoring” of the stakeholders in the national forestry sectors might impede major
 32562 improvements in the development of new and more integrative governance modes and mechanisms
 32563 (Brukas, 2015; Singer & Giessen, 2017).

32564 Forest laws are the most important regulatory policy instrument in all European and East Asian
 32565 countries. However, in countries with a large share of private forest owners, where national
 32566 governments are dependent on forest owners’ willingness to protect forests, governments and
 32567 authorities are making increasing use of voluntary contracts or public-private partnerships with private
 32568 forest owners to protect biodiversity (Amacher, Ollikainen, & Uusivuori, 2014; Primmer, Paloniemi,
 32569 Similä, & Barton, 2013). In this mixed “public-private area”, financial payment is the main instrument
 32570 applied to incentivize targeted private forest management activities. However, the suitability and
 32571 effectiveness of such initiatives depend on the appropriateness of the programme design as well as on
 32572 the institutional context, and might vary from country to country, as demonstrated by voluntary
 32573 environmental agreements in forestry (Forest Stewardship Council, Programme for the Endorsement

of Forest Certification) or fishery (Marine Stewardship Council) (Prakash & Potoski, 2012; See also 6.3). Further, due to competition rules, European Union regulation constrains the use of these instruments in ways that would reward biodiversity impacts (Raitanen, Similä, Siikavirta, & Primmer, 2013). In Eastern European countries the compulsory forest planning process is often conducted by governmental agencies without active participation of forest owners, thereby impeding the enhancement of learning and adaptation capacities (Bouriaud et al., 2013) (see also synthesis **Table 6.11**). Further, insufficient knowledge and a low priority of biodiversity conservation, a lack of planning tools and transparency, as well as limited resources, can reduce the effectiveness of policy implementation (Blicharska, Angelstam, Antonson, Elbakidze, & Axelsson, 2011; Demeter, 2016; Kirchhoff & Fabian, 2010; Krilasevic, 2010).

Concerning the private level, forest certification is often considered as one of the most important private or self-governance initiatives (see **Figure 6.2** and Chapter 4 Section 4.5.3), due to the inclusion of stakeholder groups (environmental non-governmental organizations, and social groups such as indigenous peoples and labour organizations) and forest owners in the schemes. Certification of forestry is lacking in Central Asia and Russia, and forest management planning is not a legal requirement in several countries (UNECE/FAO, 2015). Power asymmetries and a lack of transparency and accountability in private governance tend to undermine the effectiveness to achieve stated environmental objectives as well as equity-related goals among the actors involved (Auld & Gulbrandsen, 2010; Auld et al., 2008; Johansson, 2013). Furthermore, advice on concrete goal-oriented management practices is often missing (Foster, Wang, Keeton, & Ashton, 2010). In consequence, sustainable forest management may have to be pursued through trial-and-error, which may be ineffective and inefficient. Despite their shortcomings, certification schemes have shown to be particularly important for indigenous peoples such as the Sami people, who have usufruct rights to herd reindeer in approximately 30-50 % of the forest land in Norway, Finland and Sweden. Certification has, in the absence of national legislation to protect indigenous traditional use of forestry, not only opened up for collaborative arrangements between the Sami and the forest industry, but also paved the way for the Human Rights Committee to engage in this conflict (Human Rights Committee, 2005). Although conflicts still occur, certification schemes provide an important framework for the development of new policy instruments such as participatory GIS and indigenous mapping (Roturier, 2009; Roturier & Bergsten, 2006; C. Sandström & Widmark, 2007; P. Sandström, Sandstrom, Svensson, Jougda, & Baer, 2012). In addition, specifically in the private-owner context, information instruments are still crucial for integrating biodiversity conservation into forestry. Criteria and indicators, such as the six pan-European criteria for sustainable forest management, provide crucial information for policy development, assessment and communication at different governance levels (Forest Europe, 2016). Forest inventories support national planning, and planning at the local level is often merged with forest owner advice systems (Primmer, 2011).

6.5.2.3 Constraints and opportunities

Several possibly interdependent challenges have been identified for mainstreaming nature conservation in forest policy (see synthesis **Table 6.11**): (i) balancing of conservation and production aspects; (ii) integration of science and stakeholders; (iii) climate change; (iv) effective funding; and (v) conflicts with policies related to other sectors (Keskitalo & Pettersson, 2016; Makkonen, Huttunen, Primmer, Repo, & Hildén, 2015; Winkel et al., 2015). Concerning sectoral policies, a mismatch has been detected between the low degree of forest sector integration with other policy sectors on the one hand, and on the other its high potential to contribute (Sotirov et al., 2015), for example to the Bioeconomy Strategy or Rural Development Policy as well as the Water Framework Directive (European Commission, 2016c; UNEP & UNECE, 2016), see Sections 6.3.2 and 6.4.2). To utilize this

potential and to overcome the current fragmented policy framework, horizontal coordination between the different sectors (i.e. forestry, conservation, energy) is required as well as vertical coherences of policy targets and institutions at the different governance levels (international, European Union, national, regional). These targets might be hindered by decentralizing forest policy decision-making. Thus, it is advisable to supplement the current policy framework with a bottom-up process, including broad participation and conflict management processes at the different governance levels (Sotirov et al., 2015; Ulybina, 2014). As an example, (Veenman, Liefferink, & Arts, 2009, p. 202) analyzed the process of “de-institutionalization” in the Netherlands, which led to a nearly complete integration of forest policy into nature policy. They identified the four dimensions of “*discourse, power, rules and actors*”, which have been working in the same direction, as an explanation for this development. However, such a convergence is an exception rather than the rule.

Another option would be to elaborate more systematically on environmental policy integration through novel governance modes. However, countries thus need to overcome challenges related to (i) the currently established legal and policy system, and (ii) the capacity of new, private actors to be involved in policy formulation and implementation. Concerning the first aspect, (Schulz et al., 2014) compare nine European Union countries and subnational jurisdictions and analyze the relationship between property rights and economic importance on the one hand, and the degree of formally implemented “integrative nature conservation” in forest policy on the other. They found that the more important the forest sector and the more decision-making is influenced by small “peak interest organizations”, the less conservation rules are formally implemented. Related to the second aspect, Howlett & Rayner (2006) recognize the importance of private actors and interest groups in the reconfiguration of governance structures. Decentralization and participatory approaches have become important issues in the forestry sector, and are seen as measures to increase the effectiveness of forest policy. As a means to bring decision-making closer to the implementation level, four variables are most important for achieving sustainable forest management via nation-wide Forest Programmes: participation, collaboration, inter-sectoral cooperation, and long-term iterative adaptive approaches (Humphreys, 2004, p. 18). At the local level, participatory approaches such as forest collaborative arrangements or partnerships seem promising, but have so far often been underutilized (e.g., between forestry and reindeer husbandry (Roturier, Nygard, Nutti, Astot, & Roué, 2017). Impeding factors can be fragmented private ownership, strong interest groups and clientelism, established legal traditions and policy cultures. Decentralization does not necessarily mean a withdrawal of the government, because “*control by the state and self-governance by people go hand in hand.*” (Arts, 2014, p. 17). In general, such programmes make less use of participants’ inputs than they could, and the participatory processes are generally not designed to resolve conflicts or trade-offs (Primmer & Kyllönen, 2006; Saarikoski, Akerman, & Primmer, 2012).

6.5.2.4 Summary

The key aspects of an effective and sustainable integrated forest policy and management approach, including the protection of biodiversity and mainstreaming of biodiversity and nature’s contributions to people, can be summarized as: (i) bringing together different public and private actors; (ii) encouraging joint learning and developing a common understanding; (iii) identifying and addressing trade-offs; (iv) developing a coherent policy at different levels; and (v) managing conflicts by applying various policy instruments appropriately designed for the respective institutional context (Sotirov et al., 2015).

However, structural governance change happens at different speeds, to different degrees and is influenced by various factors. The scope of change can vary from changing the policy setting, while

instruments and goals remain the same, to changing setting and instruments without changing the goals, and changing all three elements (setting, instruments, and goals) of forest policy (Borrass, Sotirov, & Winkel, 2015). The degree of change depends on the national legal and policy system currently in place, as well as the readiness of interest groups to participate in the process of multi-level governance. Given the diverse character of change, it can be quite demanding for private actors to develop respective capacities and coping strategies (Juerges & Newig, 2015; Tysiachniouk & McDermott, 2016). This is particularly the case for indigenous peoples who lack the necessary organizational capacity to adapt to this change (Widmark, 2009). Furthermore, success or failure of governance shifts can be determined by external factors such as “*adjacent policy arrangements, socio-political trends and shock events*”, and internal factor such as “*policy entrepreneurs*” (Arnouts, van der Zouwen, & Arts, 2012, p. 47) (see also Chapter 4). Examples from Europe and Central Asia show that this holds for eastern as well as western countries (Blicharska et al., 2011; Borrass et al., 2015; Bouriaud et al., 2013; Brukas, 2015; Krilasevic, 2010; Vuletic et al., 2010).

6.5.3 Fisheries and aquaculture

6.5.3.1 Policy objectives

Fisheries and aquaculture policies such as the European Union Common Fisheries Policy and the European Union Strategy for Sustainable Development of European Aquaculture have the policy objectives of ensuring that fishing and aquaculture are environmentally, economically and socially sustainable and that they provide a source of healthy food for consumers. Such policies are also aimed at fostering a dynamic fishing and aquaculture industry and ensuring a fair standard of living for coastal communities (European Commission Directorate-General for Maritime Affairs and Fisheries, 2017). The fisheries sector – fisheries and aquaculture – is important from a marine ecosystem and biodiversity sustainability perspective due to its interconnectivity with, and reliance on, aquatic ecosystems (UNEP, 2014a). Indeed, globally, aquaculture has been the fastest growing food production sector of the past 40 years and now supplies more than half of the world’s fish produce. Fishing and aquaculture policy that promote overfishing or targeting of species when they are at a vulnerable stage of their lifecycle, can affect biodiversity by reducing species richness (Lee & Safina, 1995).

Fisheries pressure on biodiversity can also affect the heritable adaptations of a species and alter its characteristics and the characteristics of an ecosystem over time. Fishing and aquaculture related policies can also introduce new species to a given ecosystem. For example, the Pacific oyster was introduced to help boost Britain's declining commercial shellfish fishery. It was assumed that this species would not reproduce in Britain’s cooler waters, but it is now spreading in the wild. Fisheries policy can also cause loss of genetic variability simply by reducing a species to such a low level that there are not enough individuals in the gene pool to carry the full range of variability that once comprised the population. For example, an Irish commercial fishery for orange roughy began in the North East Atlantic in 2001 with the assistance of government grants. The fishery began as an open access, non-quota fishery. Similar to orange roughy fisheries elsewhere the fishery resulted in unsustainable fishing levels and the subsequent depletion of the fish population. Given that orange roughy is often found near deep water seamounts and cold-water corals, there was also collateral damage to cold water corals. Foley and co-authors (2011) suggest that, in the absence of the subsidies, deep water trawling for orange roughy would not have been viable and the depletion of the species by the Irish fleet would have been avoided.

32711 6.5.3.2 Governance modes and policy instruments

32712 Numerous policies and governance mechanisms attempt to control the impact of fishing and
 32713 aquaculture activities on the marine environment. At an international level the United Nations is a
 32714 leading player with bodies established under the United Nations Convention on the Law of the Sea
 32715 (UNCLOS) and United Nations Fish Stocks Agreement (UNFSA), notably the Food and Agriculture
 32716 Organization (FAO) committee on fisheries and regional fisheries management organizations. The
 32717 European Union also operated a number of policies aimed at governing fisheries and aquaculture
 32718 across European Union territorial waters. Early European Union environmental policies like the
 32719 Surfaces Water Directive and Bathing Water Directive gave way to a more comprehensive Directive in
 32720 the form of the Water Framework Directive. Given the interrelated nature of freshwater aquatic
 32721 systems, reaching eventually to coastal estuaries, saltmarshes and bays, even this more
 32722 comprehensive directive could not stand alone if aquatic habitats and ecosystems were to be managed
 32723 affectively. The Water Framework Directive, with its aim of “good ecological status”, is thus intended
 32724 to operate alongside the Marine Strategy Framework Directive, which provides policy guidelines on
 32725 management of the entire marine environment through the attainment of good environmental status.
 32726 The Marine Strategy Framework Directive itself must then operate alongside the Common Fisheries
 32727 Policy such that good environmental status can be attained. Operating in tandem with these policies is
 32728 the Habitats and Birds Directive and the Natura 2000 network.

32729 The Marine Strategy Framework Directive was adopted in June 2008 and, similarly to the Water
 32730 Framework Directive, aims to achieve good environmental status of the European Union’s marine
 32731 waters by 2020 (European Union, 2008). Given that one of the major indicators of good environmental
 32732 status under the Directive is fishing pressure levels in European Union marine waters, it is clear that its
 32733 implementation has major implications for the European Union fishing sector. In addition to the level
 32734 of fishing pressure, other fishery-related indicators of good environmental status include the
 32735 reproductive capacity of fishing stocks as well as their population age and size distribution. Since the
 32736 main policy vehicle used to manage fisheries and improve these indicators of a fishery’s status within
 32737 the European Union is the Common Fisheries Policy, the Marine Strategy Framework Directive will be
 32738 required to operate alongside Common Fisheries Policy legislation. Indeed, it is likely that only through
 32739 a successful application of the recent reforms of the Common Fisheries Policy the good environmental
 32740 status target of the Marine Strategy Framework Directive may be realized.

32741 European fishing waters are currently governed as part of the Common Fisheries Policy according to
 32742 Council Regulation (EEC) no 170/83. The Common Fisheries Policy is a collaborative effort by all
 32743 European Union member States to ensure the sustainable governance of European Union fisheries.
 32744 The policy tries to ensure sustainable fishing practice by setting “total allowable catch”, limiting the
 32745 number of days at sea (fishing effort), restricting the use of certain fishing gear (technical conservation
 32746 measures (TCM)) and reducing overcapacity in the European Union fishing fleet (through fleet
 32747 decommissioning) (European Commission, 2011b). Total allowable catch levels are set for each
 32748 European Union fishing zone. **Figure 6.11** shows the international fishing zones defined by the
 32749 International Council for the Exploration of the Sea. The quantity of fish landed from each zone by the
 32750 European Union fleet is recorded and quotas are set under the Common Fisheries Policy for those
 32751 zones within European Union jurisdiction). The procedure for carrying this out is provided for by
 32752 Council Regulation (EEC) no 170/83 of 1983 and establishes a system for the conservation and
 32753 management of fishery resources. In 2013, the European Parliament and Council of Ministers agreed
 32754 on a new and reformed European Common Fisheries Policy to be implemented across all European
 32755 Union marine waters in January 2014. One outcome of the agreements is that quotas and the use of
 32756 species’ maximum sustainable yields will remain the primary means by which member States attempt
 32757 to achieve sustainable fisheries.

Other mechanisms to achieve sustainable fisheries are also being considered. For example, closed areas are tools proposed through the ecosystem-based management approach for fisheries. These can be temporary closures or more permanent marine protected areas (Andrello, Jacobi, Manel, Thuiller, & Mouillot, 2015; Hynes, Gerritsen, Breen, & Johnson, 2016; Lagabriele et al., 2014). Management in marine protected areas is very diverse, with local restrictions ranging from “no-take” to zoning or gear limitations. While there is consistent evidence for the positive effects of full and partial protection on the density and biomass of protected species, it has been shown that fishers may feel alienated from the management process and may feel more comfortable with reserve managers and marine protected area regulations if they are involved in the management process (Himes, 2003).

Elsewhere, regional fisheries management organizations are international organizations formed by countries with fishing interests in an area. Their role is to guarantee the management, conservation and sustainable exploitation of the fish and other marine species by setting catch limits, technical measures and control obligations. In Central Asia, an example of a regional fisheries management organization is the Central Asian and Caucasus Regional Fisheries and Aquaculture Commission (CACFish). The objectives of CACFish are to promote the development, conservation, rational management and best utilization of living aquatic resources, as well as the sustainable development of aquaculture in Central Asia and the Caucasus. Following the United Nations Conference on Sustainable Development (Rio+20), United Nations efforts have also focused on the launching of an Implementing Agreement under United Nations Convention on the Law of the Sea for the conservation and sustainable use of marine biodiversity in areas beyond national jurisdiction.

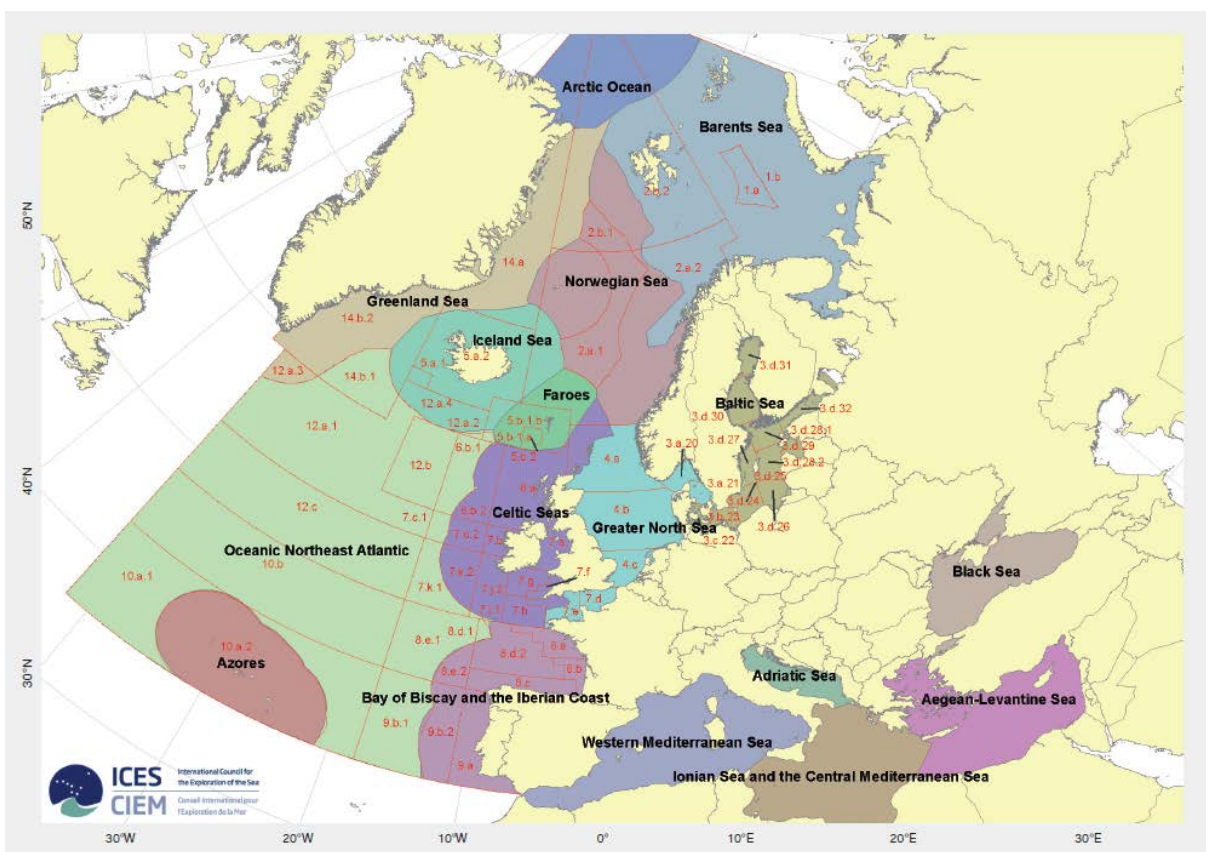


Figure 6.11: Ecoregions including fishing zones of the International Council for the Exploration of the Sea (Subdivisions with red borders are ICES fishing zones). Source: ICES (2017)

32782 6.5.3.3 Constraints and opportunities

32783 Political problems with fisheries management and with maintaining the scientifically recommended
 32784 maximum sustainable yield throughout the political process have been documented within the
 32785 European Union (Daw & Gray, 2005). Despite these highlighted problems, the reforms of the Common
 32786 Fisheries Policy indicate that the degree to which scientific recommendations of maximum sustainable
 32787 yield are adhered to in practice will be far more binding than has been the case historically, such that
 32788 by 2020, all stocks are to be managed at maximum sustainable yield. Negotiations that will take place
 32789 on the allocation of quota in UK versus non-UK waters following Brexit are also likely to add to the
 32790 complexity of fisheries management at a European level.

32791 Further changes to the Common Fisheries Policy include a banning of all discards and the adoption of
 32792 multi-annual and multi-species planning. The new landing obligation means that from 1 January 2015
 32793 onwards fishermen in certain parts of the European Union must land all the fish they catch. By 2019,
 32794 all fishermen will have the same obligation. This means that the quantity of any fish stock that can be
 32795 sustainably harvested will be determined on the basis of interaction with, and impacts upon, other
 32796 species and marine habitats. If fisheries are to become sustainable, the impact of fishing for a single
 32797 commercial species on other commercial species will be of great importance. It is foreseeable that, in
 32798 waters where the by-catch of biologically sensitive species is high, quotas for any target species in
 32799 question will be set lower than their potential maximum sustainable yield level would be had they
 32800 been considered in isolation.

32801 According to the European Commission, European Union legislators will only define the general
 32802 framework, the basic principles and standards and the overall targets of the Common Fisheries Policy,
 32803 while member States will themselves develop recommendations on the actual implementing measures
 32804 (European Commission, 2016d). National policymakers will thus be charged with the responsibility of
 32805 deciding on and implementing the medium-term management initiatives that will achieve the overall
 32806 targets of the Common Fisheries Policy. In this new policy environment, when setting species' total
 32807 allowable catches, fishery managers must pay particular attention to the multispecies impact of
 32808 harvesting an individual species, not least, the impact on other commercial species within the fishery
 32809 and in neighbouring fisheries.

32810 Models assisting the management process that follows the reforms will need to assess the
 32811 environmental and ecosystem impacts of commercial fishing activity. In addition, behavioural
 32812 economic models have a role to play, since they offer a framework for attempting to describe the
 32813 response of fishermen to any policy changes. According to Fulton and co-authors (Fulton, Smith, Smith,
 32814 & van Putten, 2011), human behaviour, and in particular fishermen behaviour, is almost never explicitly
 32815 considered by fisheries scientists in the assessment and management process. They posit that the
 32816 uncertainty generated by unexpected resource-user behaviour is as critical as ecosystem and
 32817 environmental uncertainty because it has unplanned consequences and leads to unintended
 32818 management outcomes. Indeed, technical measures can lead to results which actually work directly
 32819 against specific sustainability targets for which they are designed (Briand, Heckeley, Matulich, &
 32820 Mittelhammer, 2004; Dinmore, Duplisea, Rackham, Maxwell, & Jennings, 2003; Polacheck & Davies,
 32821 2008; White & Mace, 1988). In relation to the Marine Strategy Framework Directive, clarification is still
 32822 needed as to how biodiversity and the goods and services of marine ecosystems can contribute to the
 32823 Directive's good environmental status target and this needs to be further developed. For this, marine
 32824 and coastal ecosystem services indicators and models for assessment (including fisheries and food
 32825 webs) need to be further developed to demonstrate how they can contribute to good ecological status
 32826 (Liquete et al., 2013).

32827 A recent report by the Central Asian and Caucasus Regional Fisheries and Aquaculture Commission
32828 (CACFish, 2016) highlighted a number of constraints in implementing the code of conduct for
32829 responsible fisheries in the Central Asian and Caucasus region. The main constraints highlighted were
32830 related to inadequate scientific research, statistics and access to information, insufficient budgetary
32831 resources and institutional weaknesses, insufficient fisheries monitoring, control and surveillance and
32832 overcapacity in fisheries.

32833 The European Union Strategy for Sustainable Development of European Aquaculture sets out the
32834 European Union's policy for the development and growth of aquaculture. The original strategy of 2002
32835 was considered to have been successful in the areas of environmental management, food safety and
32836 quality, but has not resulted in growth of production in the sector across the European Union, in
32837 contrast with the rest of the world (European Commission, 2009a). In 2009, the Commission undertook
32838 a review of the strategy. The renewed 2013 strategy sought to identify causes of the European Union
32839 stagnation and identified policy actions to address competitiveness, sustainability and governance in
32840 the sector. Following the review, the Commission published Strategic guidelines for the sustainable
32841 development of aquaculture in the European Union (European Commission, 2013e). The strategic
32842 guidelines implement the new Common Fisheries Policy approach to promoting aquaculture through
32843 an open method of coordination: a voluntary process for cooperation based on strategic guidelines
32844 and multiannual national strategic plans identifying common objectives and, where possible,
32845 indicators to measure progress towards these goals. These plans have now been published, and the
32846 European Commission has produced a summary of the implementation (European Commission,
32847 2016e).

32848 There are also three European Commission regulations that establish a framework governing
32849 aquaculture practices in relation to alien and locally absent species to assess and minimize the possible
32850 impact of these and any associated non-target species on aquatic habitats (Council Regulation (EC) No
32851 708/2007 of 11 June 2007; Commission Regulation (EC) No 506/2008 of 6 June 2008 amending Annex
32852 IV to Council Regulation (EC) No 708/2007; Commission Regulation (EC) No 535/2008 of 13 June 2008
32853 laying down detailed rules for the implementation of Council Regulation (EC) No 708/2007).

32854 Aquaculture can also be affected by sectoral activity on land (e.g. agricultural runoff) and on the coast.
32855 The link between freshwater systems, coastal habitats and the sea at large is catered for in a policy
32856 sense via a new policy framework, which builds upon previous integrated coastal zone management
32857 legislation and incorporates marine spatial planning to account for at-sea projects and development,
32858 such as new aquaculture facilities, as well as that pertaining to areas of coastal proximity. These two
32859 sets of policy, run concurrently, are intended to allow stakeholders, coastal managers and other
32860 relevant parties to cooperate in designing coastal and marine management initiatives that promote
32861 environmental sustainability, but also allow for local economic development (Domínguez-Tejo,
32862 Metternicht, Johnston, & Hedge, 2016). It has also been shown that intensive freshwater aquaculture
32863 can deplete groundwater supplies. For example fish farming was found to be a major contributor to
32864 the depletion of underground and surface water resources in the Ararat Valley of Armenia (Trifonova,
32865 2016).

32866 In addition to the now extensive (and growing) legislation that exists for marine and coastal
32867 management, the European Union integrated marine policy is intended to act almost as a buffer
32868 between the various pieces of legislation in this area and a stopgap for arising maritime issues that do
32869 not fall under the jurisdiction of any of the aforementioned legislations. Furthermore, the
32870 Environmental Impact Assessment Directive, the Strategic Environmental Assessment Directive, the
32871 Habitats Directive, Water Framework Directive and Marine Strategy Framework Directive also
32872 influence the potential development of aquaculture in environmentally sensitive areas and its impact
32873 on marine ecosystems.

32874

32875 **6.5.3.4 Summary**

32876 European Union, Eastern European and Central Asian environmental policy relating to marine and
 32877 coastal areas is still very much under development, but the rate of change is rapid and transforming
 32878 the face of marine environmental management. Fisheries and aquaculture management
 32879 methodologies that attempt to incorporate spatial and integrated methodologies and which can help
 32880 to balance the environmental and economic trade-offs of economic development and natural
 32881 conservation will be important for the success of this transformation. To date, however, successful
 32882 governance of marine fisheries remains elusive. In a recent article, Colloca and co-authors (2017) point
 32883 to *“a worrisome picture where the effect of poorly regulated fisheries, in combination with the ongoing*
 32884 *climate forcing and the rapid expansion of non-indigenous species are rapidly changing the structure*
 32885 *and functioning of the ecosystem”*, and add that *“the management system implemented in the region*
 32886 *appears too slow and probably inadequate to protect biodiversity and to secure fisheries resources for*
 32887 *future generations”*. Indeed, across the European Union, the continued misalignment of short-term
 32888 political objectives for jobs and revenue maximization and the scientific community’s long-term
 32889 objectives for the sustainability of marine biodiversity remain issues to be resolved. The practical
 32890 implementation of the landing obligation under the Common Fisheries Policy is also an area that will
 32891 require close monitoring and active adaption if it is to be successful. While many countries in Central
 32892 Asia and the Caucasus are now employing adaptive management and conservation measures in
 32893 accordance with FAO Code of Conduct for Responsible Fisheries, the region continues to face
 32894 challenges caused by significant declines in total fish biomass in recent decades. According to CACFish
 32895 (2016) the development of regional education and training programmes as well as a researcher
 32896 exchange scheme with countries that have successfully implemented integrated approaches to
 32897 fisheries management, are avenues to be explored to reverse the declines.

32898

32899 **6.5.4 Resource extracting sectors and manufacturing**32900 **6.5.4.1 Policy objectives**

32901 *Energy.* As the focus on economic growth continues worldwide, energy remains a key issue in boosting
 32902 production and consumption. Meanwhile, energy choices and policies are directly important for
 32903 nature’s contributions to people as they reshape ecological systems and the environment. This
 32904 concerns both renewable and non-renewable energy systems which, as Holland and co-authors
 32905 (Holland, Scott, & Hinton, 2016) show, have considerable impacts on nature’s contributions to people
 32906 through extensive infrastructure and habitat loss and may thus negatively affect terrestrial, marine
 32907 and freshwater realms. Low carbon development, energy efficiency and reduction of the impacts of
 32908 energy are among the policy objectives in Europe and Central Asia. In addition, the European Union's
 32909 Renewable Energy Directive sets a binding target of 20% renewable sources for the entire energy
 32910 consumption by 2020, and at least 27% by 2030, in the European Union as a whole. Another binding
 32911 directive is the 2012 Energy Efficiency Directive, which sets measures to help the European Union reach
 32912 its 20% energy efficiency target by 2020. However, in Eastern Europe and Central Asia, all
 32913 “environmental” targets and guidelines for the energy sector are largely focused on reducing carbon
 32914 emissions and do not explicitly address the degradation of habitats and loss of species and nature’s
 32915 contributions to people. An extreme example can be found in Mongolia, where emission reduction
 32916 targets and other energy and environment policies focus on supporting large hydropower
 32917 construction. Although Mongolia falls outside the boundaries of Europe and Central Asia, such policies
 32918 may adversely affect rivers of the region and Lake Baikal World Heritage Site in Russian Federation.

32919 *Mining.* Mining is most relevant to terrestrial environments. Fluvial ore mining (placer mining) has
 32920 been widespread for several millennia (BRGM, 2001), and marine mining in the deep-sea (ISA, 1999)
 32921 and marine shelf (United Nations, 2016) is rapidly expanding. Placer gold mining has had widespread
 32922 and severe impacts on several river ecosystems in Eurasia, particularly in Russia, China and Mongolia,
 32923 destroying riverine habitats, creating serious pollution and transforming sedimentation processes. This
 32924 practice is often uneconomical, bringing marginal financial returns and surviving only because no fines
 32925 are charged for environmental degradation in remote wilderness areas (Egidarev & Simonov, 2015).
 32926 Marine mining operations may create sediment suspension which, at large scales, can harm benthic
 32927 fauna and flora; and may also change the nutrient balance, causing changes in species assembly ratios.
 32928 Auxiliary mining operations are also likely to damage mining sites, thus affecting local natural habitats
 32929 (Van Dover et al., 2011). Hence, in relation to biodiversity and nature's contributions to people, the
 32930 main objective of mining policies and any particular mining activity is often to restrict both direct and
 32931 indirect impacts to the site perimeter and to have an *a priori* rehabilitation programme in place. In
 32932 some cases, the aim is to leave as small a footprint as possible, whereas in others a complete change
 32933 of landscape may be unavoidable. Although the awareness of the negative impacts of mining is high
 32934 among involved actors, and relevant international conventions and agreements are signed by most
 32935 countries in Europe and Central Asia, much remains to be done to reduce the negative effects of mining
 32936 on biodiversity and nature's contributions to people.

32937 *Manufacturing.* Reduction of the impacts of manufacturing on nature's contributions to people is the
 32938 main regulatory policy objective. Sustainable production and consumption as well as a transition
 32939 towards a "circular economy" are among the emerging political goals that can contribute to achieving
 32940 some of the sustainable development goals. The circular economy concept gains prominence as
 32941 resources become scarcer and environmental degradation increases with increasing production and
 32942 consumption of goods and services. A circular economy is considered to be a solution that harmonises
 32943 ambitions for economic growth with environmental protection (Lieder & Rashid, 2016). Its origins can
 32944 be traced back in the fields of both ecology and economics (Murray, Skene, & Haynes, 2017). Despite
 32945 growing political will to pursue such strategies, it is important to point out that action is still needed.
 32946 This idea is clearly expressed in the conclusions of the Council of the European Union on the European
 32947 Union action plan for the circular economy (European Union, 2016a). The European Council (2016),
 32948 while recognizes that a "*circular economy offers great potential to achieve sustainable growth and
 32949 boost the European Union's competitiveness, create jobs, decrease the European Union's dependency
 32950 on non-renewable primary raw materials, achieve resource and energy efficiency and a smaller
 32951 environmental footprint, promote locally produced goods, prevent and minimize waste generation,
 32952 protect nature and natural capital, strengthen ecological resilience and mitigate greenhouse gas
 32953 emissions, thus contributing to the 2030 Agenda for Sustainable Development and the world-wide
 32954 efforts towards a green economy*". The Council also states "*the importance of developing a system of
 32955 valuation of natural capital through appropriate indicators for monitoring economic progress and
 32956 further developing ecosystem accounts*" (European Council, 2016). Still, there is a need for
 32957 mainstreaming biodiversity and ecosystem services and at the same time there are many opportunities
 32958 to improve the situation (see synthesis **Table 6.11**).

32959 In Eastern Europe and Central Asia, initial decline in manufacturing after the dissolution of the Soviet
 32960 Union significantly reduced pressures on natural resources. However, a challenge the regions face
 32961 today is how to address environmental degradation re-emerging with the recovery and fast
 32962 development of the sector.

32963

32964 6.5.4.2 Governance modes and policy instruments

32965 *Energy.* Energy sector management is conducted mainly through national authorities dealing with
 32966 energy, environment, climate and natural resources (see also Section 6.4.2 on environmental policies).
 32967 Such ministries and their associated committees or agencies are responsible for managing the energy
 32968 sector by developing national strategic energy plans, promoting energy efficiency, regulating energy
 32969 conservation, developing alternative or renewable energy, and disseminating energy technologies. In
 32970 addition, according to the Lisbon Treaty (European Union, 2007c), the European Union energy policy
 32971 aims to ensure the functioning of the energy market; to ensure security of energy supply in the Union;
 32972 to promote energy efficiency, energy saving, and the development of new and renewable forms of
 32973 energy; and to promote the interconnection of energy networks (European Parliament, 2017). Article
 32974 194 of the Treaty on the Functioning of the European Union (European Union, 2016c) lists several
 32975 specific energy provisions including energy supply, energy networks, coal and nuclear energy. Last, but
 32976 not the least, the Biofuels Directive (Directive 2003/30/EC) aims to promote the use of biofuels or
 32977 other renewable fuels for transport. The initial target was to ensure that biofuels and other renewable
 32978 fuels are placed on European Union member State markets at a share of a minimum 2% by the year
 32979 2005, which was not attained. Later the Directive was replaced by Directive 2009/28/EC, which
 32980 introduced a target of 10% by 2020. Such targets, if not coordinated with other policy areas, can easily
 32981 lead to conflicts with biodiversity conservation or regulating and non-material contributions of nature
 32982 to people (see **Box 6.1** and Chapter 2, Section 2.3.1.2).

32983 There are various studies on multiple instruments that are utilized in the energy sector. Property and
 32984 access rights are defined and responsibility is ensured in most of the region, to the greatest extent in
 32985 Western and Central Europe, and developing in the transition economies of Eastern Europe and
 32986 Central Asia. Governments can provide financial incentives, including direct payments, tax credits,
 32987 payments for environmental services and grants, to different market actors (see synthesis **Table 6.11**).
 32988 Besides, Governments may introduce mandates with sustainability requirements and national
 32989 standards for certification. Governments can either recognize the sustainability standards that are
 32990 usually developed jointly by various stakeholders or set their own standards and sustainability
 32991 requirements. These standards are generally useful as they rely on local circumstances, and answer
 32992 local needs and concerns. Finally, capacity building is crucial in enabling the development of a
 32993 sustainable energy sector. Such programmes consist of information sharing and dissemination,
 32994 education and research, and training. Rossi & Cadoni (Rossi & Cadoni, 2012) stress that several factors,
 32995 such as the financial resources available and the administrative and enforcement capacity of the
 32996 government, determine the success of these instruments for the bioenergy sector in any country.
 32997 Similar categories of policy instruments may apply to other types of energy such as wind and solar
 32998 power where sustainability is a concern. An example on Finland's bioenergy sector is provided by
 32999 Makkonen and coauthors (Makkonen et al., 2015), who concentrate on land-use aspects. They show
 33000 that forest bioenergy, which is an asset exchanged in the market, is governed with more explicit
 33001 instruments (such as financing the tending of young stands, and the energy wood harvesting from
 33002 young forests) than is carbon sequestration, whose policies remain relatively abstract, possibly due to
 33003 the late emergence and high uncertainty embodied in these markets.

33004 The use of market-based instruments, such as energy-related taxes and subsidies, is common in Europe
 33005 and Central Asia. Environmental taxes usually cover "energy taxes" according to the definitions of the
 33006 OECD, the International Energy Agency and the European Commission, and are defined as "any
 33007 compulsory, unrequited payment to general government levied on tax-bases deemed to be of particular
 33008 environmental relevance", where the "tax bases" are comprised of energy products, motor vehicles,
 33009 waste, measured or estimated emissions, natural resources, etc. (OECD, 2006b). According to the
 33010 OECD statistics, environmentally-related tax revenue as a share of GDP as of 2014 is the highest in

Denmark (4.11%), followed by Slovenia (3.86%), Italy (3.85%), Turkey (3.83%), and Israel (2.97%), and energy taxes made the most of these tax revenues. In fact, around 70% of all environmentally related taxes are raised on energy products, including vehicle fuels. However, almost zero effective energy tax rates per tonne of CO₂ can be observed in several countries such as Russia. A study on Turkey found that the country pays among the most for fuels – especially gasoline and diesel – in the world due to a special consumption tax. Yet, it is observed that differential taxation of fuels fails to attain environmentally friendly aims. In the absence of any viable sources of alternative energy, final consumers suffer from the very low elasticity of demand for energy sources. Without any provision of alternative sources of energy, (indirect) taxation itself does not help to reduce the utilization of fossil fuels, but leaves households and firms stuck in expensive and ecologically unsustainable patterns of consumption and production (Acar, Challe, Christopoulos, & Christo, 2014). Meanwhile, renewable energy development is supported via financial incentives such as direct payments, tax credits, feed-in tariffs, in the European Union, Azerbaijan, Kazakhstan, and Turkey (see e.g. Acar, Kitson, & Bridle, 2015; IEA/IRENA, 2016; OECD, 2016b, respectively).

Substantial fossil fuel subsidies across the whole region, especially in Eastern Europe and Central Asia, pose major challenges for the environment. According to International Energy Agency statistics, Turkmenistan, Uzbekistan, Russia, Azerbaijan, and Kazakhstan were among the major provider countries of fossil fuels worldwide with the highest shares of such subsidy of GDP in 2015 (15.4%, 9.8%, 2.3%, 1.9%, and 1.8% respectively). Most of these subsidies are wastefully consumed and counter-productive to energy-efficiency as well as clean energy approaches.

Mining. While marine mining is transboundary by nature and regulated by international policies, regulations and treaties (ISA, 2002), terrestrial mining is regulated mainly by national policies, which, in the European Union, are based on European Union directives (Hámor, 2004). Mining and quarrying are regulated by policies applying to operational actions (BRGM, 2001) and through legislation regulating various types of waste that are categorized as mining waste (European Community, 1975). European Union mining operation regulations have developed since the general guidelines of the 75/442/EEC directive and currently new mining permits demand the application of the “*best available technique – integrative pollution prevention and control*” (BAT-IPPC) techniques, for mining operations as well as waste treatment. The choice of best available technique applied for tailings or waste-rock management depends mainly on an evaluation of three factors, namely cost, environmental performance and risk of failure (European Commission, 2009b). European Union directives for mining and quarrying are accordant with international regulations such as US mining laws and Australian laws of mining (Chambers, 2008).

In Central Asian countries, in general, there is no legal framework for mining regulation, which addresses its impact on biodiversity and nature’s contributions to people. Moreover, since mining and quarrying are the major developing industries for most Central Asian countries, the ability to apply environmental restrictions is limited. In several countries, the lingering effects of Soviet-era hazardous ores and complex mining persist, such as the release of toxic radioactive mining waste from mining operations (USAID, 2001). As there is no evident improvement in either national mining regulations or pollution prevention infrastructures, the negative impact of mining on human environments in general, and transboundary issues in particular, are visible. Yet, several Central Asian regulative transboundary strategies for mining waste remediation are being promoted by United Nations-affiliated NGOs (UNEP, 2012). Moreover, some countries, such as Georgia and Kazakhstan, voluntarily develop “low emission development strategies” to promote the transition to climate-resilient, low emission, sustainable development (USAID, 2017) via their mining and energy industries. Hence, there are many opportunities for mainstreaming biodiversity in the mining sector (see synthesis **Table 6.11**).

33057 In the early 21st century, the governments of China, Mongolia and several Russian provinces assessed
 33058 operations of placer gold mining. In north-eastern China, placer gold mining has been fully halted as a
 33059 part of comprehensive efforts to preserve and restore large forest ecosystems as well as ecosystem
 33060 functions and the services they provide. In Mongolia, a similar logic led to an NGO-induced enactment
 33061 in 2009 of a *“law to prohibit mining in forests, water protection zones and river sources”*, but
 33062 implementation has been inconsistent and largely unsuccessful. In Russian Siberia, despite being
 33063 presented with overwhelming evidence of extreme harm from the placer gold mining, regional
 33064 authorities continue to allow this activity on the premise that it provides local employment. As a result
 33065 Russia received an influx of placer gold mining equipment and miner crews from adjacent China, where
 33066 this activity is fully prohibited (Simonov et al., 2013).

33067 *Manufacturing.* The uptake of ecosystem services by the private sector is a growing trend following
 33068 pioneer initiatives such as The Economics of Ecosystems and Biodiversity (TEEB), that dedicated one
 33069 of its major reports to business (TEEB, 2012), and the Ecosystem Valuation Initiative from the World
 33070 Business Council for Sustainable Development (WBCSD). The manufacturing sector is not an exception
 33071 to this trend as evidenced below. In the European Union, there has been no consistent sectoral
 33072 regulatory framework built upon the concept of ecosystem services or ecosystem services-based
 33073 metrics applying directly to the manufacturing sector so far. The European Union Environmental
 33074 Liability Directive (European Union, 2004) and the Water Framework Directive (European Community,
 33075 2000) are perhaps two of the most prominent examples of regulatory instruments applying to the
 33076 manufacturing sector. Such directives can rapidly evolve into an explicit recognition of the ecosystem
 33077 services concept and ecosystem services-based metrics, once considering their current wording,
 33078 scope, and objectives. Despite this apparent absence of regulatory frameworks, it is important to recall
 33079 that the European Union’s environmental legislation is complemented by a variety of other non-
 33080 binding policy instruments such as strategies, programmes, and action plans to address the wider use
 33081 of terrestrial and marine resources. In this regard, the EU Biodiversity Strategy to 2020 (European
 33082 Commission, 2011a) is an important step towards mainstreaming the concept of ecosystem services
 33083 and associated metrics into different policies in the short term (Matzdorf & Meyer, 2014), including
 33084 those regulating the manufacturing sector. The private sector is encouraged to analyze the impacts,
 33085 dependencies, opportunities and risks of individual sectors as they relate to biodiversity and ecosystem
 33086 services (CBD, 2012; X1/7 – Business and biodiversity).

33087 While emerging regulatory frameworks and policy context are motivating the private sector’s interest
 33088 in nature’s contributions to people, other factors are shaping this new corporate management
 33089 paradigm, regardless of the sectors of economic activity. As pointed out by the TEEB-initiative (TEEB,
 33090 2012, p. 29), *“the idea that biodiversity and ecosystem services have economic value is scarcely
 33091 reflected in the conventional measures used to assess and report on company performance, and to
 33092 weigh alternative business opportunities and risks. As a result, business decisions are made based on a
 33093 partial understanding of environmental costs and benefits”*. Hence, the new paradigm aims to
 33094 counteract business-as-usual corporate decision-making. Business activities may give rise to
 33095 externalities regarding ecosystems and their services and their internalization in product value calls for
 33096 different policy instruments ranging from voluntary to mandatory. The World Business Council for
 33097 Sustainable Development, while recognizing that all business activities not only depend on, but also
 33098 affect, nature’s contributions to people, declares that corporate strategy should face this proactively
 33099 and integrate the risks and opportunities arising from the interdependence in strategy and
 33100 management goals (see **Table 6.10** for an overview of risks and opportunities).

33101 Circular economy practice is gaining political support in many regions including the European Union.
 33102 In December 2014, the European Parliament adopted the communication from the European
 33103 Commission, *“Towards a Circular Economy: a zero-waste programme for Europe”* (European

33104 Commission, 2014c). This communication and the associated legislative package are related to the
 33105 broad context of the European Union's 2020 strategy, "*a strategy for smart, sustainable and inclusive*
 33106 *growth*" (European Commission, 2010).

33107 To provide incentives for the sustainable use of natural resources in manufacturing, various legal and
 33108 economic tools have been applied. For instance, in Uzbekistan, licensing, permissions, export and
 33109 import certification, and quotas have been introduced and national systems of assessment,
 33110 monitoring, and environmental audit developed, to assess economic activities, which potentially have
 33111 environmental impact. Environmental insurance, preferential taxation and eco-labeling systems are
 33112 planned within the context of the Batumi Initiative on Green Economy (BIG-E) (The State Committee
 33113 for Nature Protection of the Republic of Uzbekistan, 2017). Similarly, the national biodiversity strategy
 33114 and action plan of Russia (CBD, 2016c) recognizes the importance of nature's contributions to people
 33115 (Russian Academy of Sciences, 2001). However, biodiversity is mainly perceived from the consumption
 33116 perspective (i.e. as a source of marketed products such as timber and fish) in this report, whereas the
 33117 diverse values of ecosystems are not taken in the account. Hence, there are many opportunities for
 33118 policy makers to improve the situation (see synthesis **Table 6.11**).

33119

33120 *6.5.4.3 Constraints and opportunities*

33121 *Energy.* Despite the importance of the energy sector, it is lacking coordination and regulation and, as
 33122 such, it is considered inefficient. According to Florini & Sovacool (2009), there are "*enormous gaps in*
 33123 *the international system's capacity to manage energy commodities, address their externalities, and*
 33124 *ensure a successful transition over time to low-carbon sources*". The energy sector both at the national
 33125 and the international level is thus governed in a piecemeal fashion, mostly through ad-hoc responses,
 33126 involving a number of actors and creating an incoherent policy landscape of uncoordinated efforts
 33127 (Dubash & Florini, 2011; Filatova, 2014; Florini, 2011; Florini & Dubash, 2011; Florini & Sovacool, 2009).
 33128 Due to the extraordinary importance of energy transition and the tipping points in relation to climate
 33129 change, there are, however, numerous examples of global or regional efforts to improve the
 33130 governance of energy and make it more secure, affordable and sustainable, such as the European
 33131 Union's Energy Union.

33132 There are also constraints regarding the use of widely-established energy policies and policy
 33133 instruments. As reviewed and demonstrated in Chapters 3 and 4, all known renewable energy sources
 33134 can have consequences for biodiversity and animal migration. For aquatic and semi-aquatic fauna,
 33135 hydropower presents by far the greatest array of problems in terms of diversity and severity of impacts
 33136 (CMS, 2014; Hogan, 2011). Environmental policy of the largest Russian hydropower company Rushydro
 33137 states that further development of the sector is constrained primarily by the fact that most suitable
 33138 dam locations are in wilderness areas that are known as key habitats for endangered species (PAO
 33139 Rushydro, 2016). Oil, gas and coal extraction or exploration in many parts of Europe and Central Asia
 33140 (e.g. Germany, Kazakhstan, Uzbekistan, Tajikistan) as well as extraction of uranium and other minerals
 33141 (e.g. Kazakhstan) lead to biodiversity losses. Apart from the conventional sources of energy, mainly
 33142 consisting of fossil fuels, hydraulic fracturing (or fracking) also puts pressure on the environment and
 33143 ecosystems causing potential water and soil contamination from surface leaks or from improperly
 33144 designed well-casing, spills of improperly treated water, and increased competition for water usage
 33145 (UNEP, 2012).

33146 Initiatives like "green economy" in Kazakhstan target clean and renewable energy development as well
 33147 as water conservation; however, they embody the risk of paying more attention to energy supply and
 33148 less to biodiversity. It is axiomatic that, even if an energy source is generally clean, it may still have
 33149 negative implications for nature's contributions to people arising from the size or construction of

power plants, the location of wind turbines on bird migration routes, the location of solar panels in agricultural land, hydropower impacts on river ecosystems, and stream restoration impacts on ecosystem functioning. Hastik and co-authors (Hastik et al., 2015) specifically focus on renewable energy policy in the Alpine region. As mountains are rich in biodiversity and provide scenic landscapes, they contribute high non-anthropocentric and cultural value. Attempts to increase renewable energy development in these mountains creates concerns about preservation of these values and give rise to land use conflicts.

Substantial fossil fuel subsidies in Europe and Central Asia are another major constraint. It is significant that G20 leaders committed to “*rationalize and phase out over the medium term inefficient fossil fuel subsidies that encourage wasteful consumption*” in 2009 (G20 Information Centre, 2009) and this engagement was later endorsed by the Asia-Pacific Economic Cooperation forum. Currently the topic of fossil fuel subsidies is gaining momentum in a post-Rio+20 context. The recommendation to gradually phase out fossil fuel subsidies has ranked as one of the most highly supported recommendations (66% of support) among the Rio Dialogues and Rio Votes processes (see: <http://vote.riodialogues.org/results2.html#4>). The reform of environmentally harmful subsidies is also part of the European Union’s 2020 strategy.

Low carbon transition entailing a switch towards cleaner fuels, renewable energies or cleaner technologies can create new opportunities in terms of reduced biodiversity impact and greenhouse gas emissions. The shift towards zero-emission energy production offers additional economic benefits.

Mining. The key issues that are addressed for the prevention of mining waste’s negative environmental impact consist of tailings or waste-rock that often contain hazardous chemical compounds, leachate generation over long periods of time and acidity effects. The collapse of any type of mining facility can have short-term and long-term effects such as flooding, blanketing or suffocating, crushing, cut-off of infrastructure, poisoning in the form of metal accumulation in plants and animals, contamination of soil, and finally direct poisoning of people or animal life. In each case, adverse environmental impacts need to be kept to a minimum.

The dynamic nature of site manipulation during the excavation process prevents meticulous rehabilitation planning because, once mining operation have ended, the restoration procedure is subjected to the regulatory leverage on the perimeter as well as financing limitations. The absence of effective monitoring procedures is another hindrance to the prevention of negative impacts of mining operations on nature’s contributions to people.

In principle, mining site rehabilitation and aftercare, once an operation ends, should strive to complete rehabilitation of the site. In the European Union, at least for the past few decades, plans for closure and site clean-up have been part of permitting to use a site, right from the planning stage onwards, and should therefore have undergone regular updating with every change in the operation and in negotiations with stakeholders. The concept of “design for closure” implies that the closure of a site is planned in the feasibility study of a new mining site and is updated during the mine’s life cycle (European Commission, 2009b). If carefully planned, mineral extraction can positively contribute to biodiversity conservation through creation of wildlife habitats during restoration (see Chapter 4.4.4.1).

Energy and mining activities and their policies may have adverse effects on indigenous populations (e.g. in the Russian Federation, Fennoscandinavia and Greenland (Koivurova, 2014)). For instance, Lavrillier (Lavrillier, 2013, p. 263-264) notes that the nomadic and settled Evenk and Even Siberian people face pollution from local mining companies, construction of dams, roads, railways and pipelines, coal power plants and other exploitation of natural resources, which bear negative impacts on the immediate natural environment of the hunters, herders and fishermen. The United Nations special rapporteur on indigenous issues and the International Work Group for Indigenous Affairs have

repeatedly monitored how the indigenous peoples in Fennoscandinavia are affected by extractive industries. Consequently, they have urged countries to ratify the International Labour Organization's Convention No. 169, and to implement the "free prior and informed consent", i.e. the principle that a community has the right to give or withhold its consent to proposed projects that may affect the lands they customarily own, occupy or otherwise use (Rohr, 2014). Norway is the first country to ratify ILO 169 (in 1990) and to implement a consultation procedure with the Sami parliament. Besides, there is an interesting governance trend emerging within the mining sector where local actors start to play an important role in governance. According to Prno and Slocumbe (2012) traditional governance modes of mining are no longer sufficient for these actors. The demand for a greater share of income and participation has urged mining companies (e.g. in Norway, Finland, and Sweden) to gain a "social license to operate" from local communities to avoid conflicts (Koivurova et al., 2015).

Manufacturing. Table 6.10 presents a compilation of business-related risks and opportunities that are relevant for the manufacturing sector as well as businesses from other sectors. Risks and opportunities are classified according to five business dimensions: operational, regulatory and legal, reputational, market and product, and financing. It identifies the actions, mechanisms or institutional arrangements in place for biodiversity and nature's contributions to people, and governance that companies can undertake voluntarily. A growing number of examples illustrate how risks and opportunities are addressed and integrated in business strategies to comply with the emerging regulatory frameworks. Manufacturing industries are classified in divisions 10-33 of the International Standard Industrial Classification of economic activities (UNSTATS, 2017). Given the diversity of industries that integrate such a categorization, it is hard to imagine one division that does not depend on or affects nature's contributions to people. More often, both the impacts and dependencies are observed at different stages of supply chains ranging from resource extraction to components manufacture, transportation, packaging, use, disposal, and recycling. The use of life cycle analysis is hence being pointed out as a means to trace and identify dependencies and impacts of the manufacturing sector on biodiversity and nature's contributions to people in the academic sphere (e.g., P. W. R. Adams, Shirley, & McManus, 2015; Bruel, Troussier, Guillaume, & Sirina, 2016; Gopalakrishnan, Bakshi, & Ziv, 2016; Teillard et al., 2016); in corporate practice or guidelines scoping (see e.g., beverage sector (Aukema & Vigerstol, 2012); the automotive sector (ten Have et al., 2016); and chemical sector (Cefic, 2013)). Despite the academic discussion on how to better integrate biodiversity and ecosystem services in life cycle analysis (see the references above), there is a growing recognition that life cycle thinking can play an important role in incorporating nature's contributions to people in corporate strategy. Other examples showing this life cycle system thinking in the manufacturing sector, while not necessarily explicitly adopting a life cycle thinking-based methodology, are provided in (Aïama, Carbone, Cator, & Challender, 2016) and Kering (2015), covering different segments of the manufacturing sector.

Table 6.10: Business-related risks and opportunities in relation to biodiversity and nature's contributions to people. Source: Adapted from World Resources Institute, Meridian Institute, World Business Council for Sustainable Development (Hanson, Ranganathan, Iceland, & Finisdore, 2012). Risks and opportunities are not exhaustive. The selection presented aims at providing insight on mechanisms to take action (on a voluntary basis).

Business dimensions		Risks	Opportunities	Corporate action
Operational	The risks and opportunities relate to the day-to-day activities, expenditures, and processes of the company.	Higher costs for freshwater due to scarcity or water quality	Identify the source of water scarcity or quality depletion and set up agreements to counteract the situation (water infiltration and depuration)	To design PES schemes (payment for ecosystem services)

Regulatory & legal	The risks and opportunities relate to the laws, government policies, and court actions that can affect corporate performance	Permit or license suspension	In some situations, restoring or protecting an ecosystem can help a business make the case to regulators that it should be allowed to expand activities elsewhere.	To develop conservation banks
Reputational	The risks and opportunities relate to the company's brand, image, or relationship with customers, the general public, and other stakeholders	Damage to brand or image due to direct or indirect environmental impact	Improve or differentiate brand	Product certification (price premium); select suppliers based on transparency.
Market & product	The risks and opportunities relate to product and service offerings, customer preferences, and other market factors that can affect corporate performance.	Changes in private sector customer preferences	Markets for certified products	Product certification (price premium) Entrance fees for owned assets (recreational opportunities)
Financing	The risks and opportunities relate to the cost and availability of capital from investors.	A business may face a higher cost of capital or more rigorous lending requirements as the financial sector becomes more attuned to the implications of ecosystem degradation for borrowers or clients.	Managers may find some lenders and socially responsible investment funds becoming more interested in investing in their companies	Environmental and social impacts disclosure.

33236

33237 **6.5.4.4 Summary**

33238 Low carbon development, energy efficiency, sustainable production and consumption, circular
33239 economy, and reduction of the impacts of the resource extracting sectors, such as energy and mining,
33240 as well as manufacturing, are among the policy objectives in Europe and Central Asia. Sectorial policies
33241 that merely target supply, security and growth usually come at the expense of biodiversity and
33242 ecosystem services, as these policies lack sufficient integration and awareness and do not reflect the
33243 real changes in diverse values. This is easily demonstrated by the array of conflicting development
33244 policy goals and sectoral policies. An integrated approach is necessary for external cost evaluation for
33245 each sector and the possible trade-offs. Evaluation of the true cost of any sectoral activity needs to
33246 consider social, health, and environmental costs together with production costs. To better govern
33247 nature's contributions to people in relation to the policies of the resource extracting sectors and
33248 manufacturing requires a well-structured assessment of the effects of these sectors on biodiversity
33249 and nature's contributions to people in different realms. As natural resources become increasingly
33250 scarce, environmental regulations become stricter and public awareness grows regarding the impacts
33251 of the extractive sectors, a new management paradigm has emerged, which focuses on managing risks
33252 and opportunities related to nature's contributions to people (depletion and conservation,
33253 respectively). Governance modes in place are diverse and reflect both top-down and bottom-up
33254 approaches. The same holds for policy instruments that can range from voluntary agreements (e.g.
33255 payment schemes) to command and control approaches. There is, nevertheless, a long way to go
33256 towards the aim of mainstreaming nature's contributions to people into corporate management and
33257 public policy.

Impacts from extractive sectors can be managed much better when decisions are made on a strategic planning level and not postponed until after an investor selects a certain project. Strategic environmental assessment presents a particularly promising tool for resolving conflict between these sectors and nature's contributions to people (see **Box 6.9**, Section 6.6.1). The assessments aim to find the best available technology alternative to satisfy certain societal needs. Recent policy advice developed by the Netherlands Commission on Environmental Assessment (NCEA, 2016) argues that decision-makers do not take an integral systems perspective through a strategic planning phase. Strategic environmental assessment may be the most promising way to decrease impacts through analysis of available resources for alternative options and the comparison of potential development outcomes (Simonov et al., 2015). Apparently, there are many options for policy makers to improve the situation by raising awareness, defining clear objectives, and designing instruments as well as policies (see synthesis **Table 6.11**).

6.5.5 Services sector

6.5.5.1 Policy objectives

A service economy is considered a mature economy, having evolved from a phase of heavy reliance on natural resources, with negative local environmental impacts (Fischer-Kowalski et al., 2011; Giljum et al., 2005). Despite dematerialization of the economy and decoupling GDP growth from environmental impact proving to be highly unfeasible in absolute terms (e.g., Pulselli et al., 2015; Ward et al., 2016), there is no doubt that managing for the services sector creates opportunities for the conservation and sustainable use of biodiversity as well as the continued provision of nature's contributions to people. Trade-offs between the economy and the environment within a service economy need to be resolved as far as possible by decision-making and policies both within the private and the public spheres.

Health and education are service areas whose implementation is crucial for the realization of universal human rights. For this reason, accessible health and education have priority with respect to economic interests and this priority can be safeguarded by policy. In Europe and Central Asia, the vast majority of countries explicitly addresses health-related benefits and risks in their national biodiversity strategies and action plans (NBSAPs) and national reports to the Convention on Biological Diversity (CBD, 2016c) (see **Figure 6.12** and Chapter 2 electronic Appendix 2.8).

Degraded ecosystems can jeopardize people's health, while biodiversity and ecosystem services play a crucial role in supporting a good health status (WHO & Secretariat of the CBD, 2015). Social health and well-being are also related to specific ecosystem services integrated into cultural motifs and practices, which are linked to concepts of sense of place, sense of identity, or sense of community. Policy objectives can be defined to regulate management of nature's contributions to people by investigating and quantifying their effects towards achieving health-related Sustainable Development Goals (i.e. Goal 3 (good health and well-being), and Goal 6 (clean water and sanitation), among others) and related targets. At the local scale, planning for urban green infrastructure and parks is more effective when coordinated with health policies and accounting for ecosystem services (Hornberg et al., 2016; Löhmus & Balbus, 2015). Improving education, capacity building and access to research and training ensures that people are becoming more aware of the importance of nature's contributions and more information is available for environmental management (see synthesis **Table 6.11**). Policy objectives to 2030 can be defined according to the Sustainable Development Goals framework, in particular Goal 4 (quality education) and its targets. Good health and quality education are conditions required to generate and diffuse sustainable behaviors that will ultimately be translated into other service areas such as sustainable tourism.

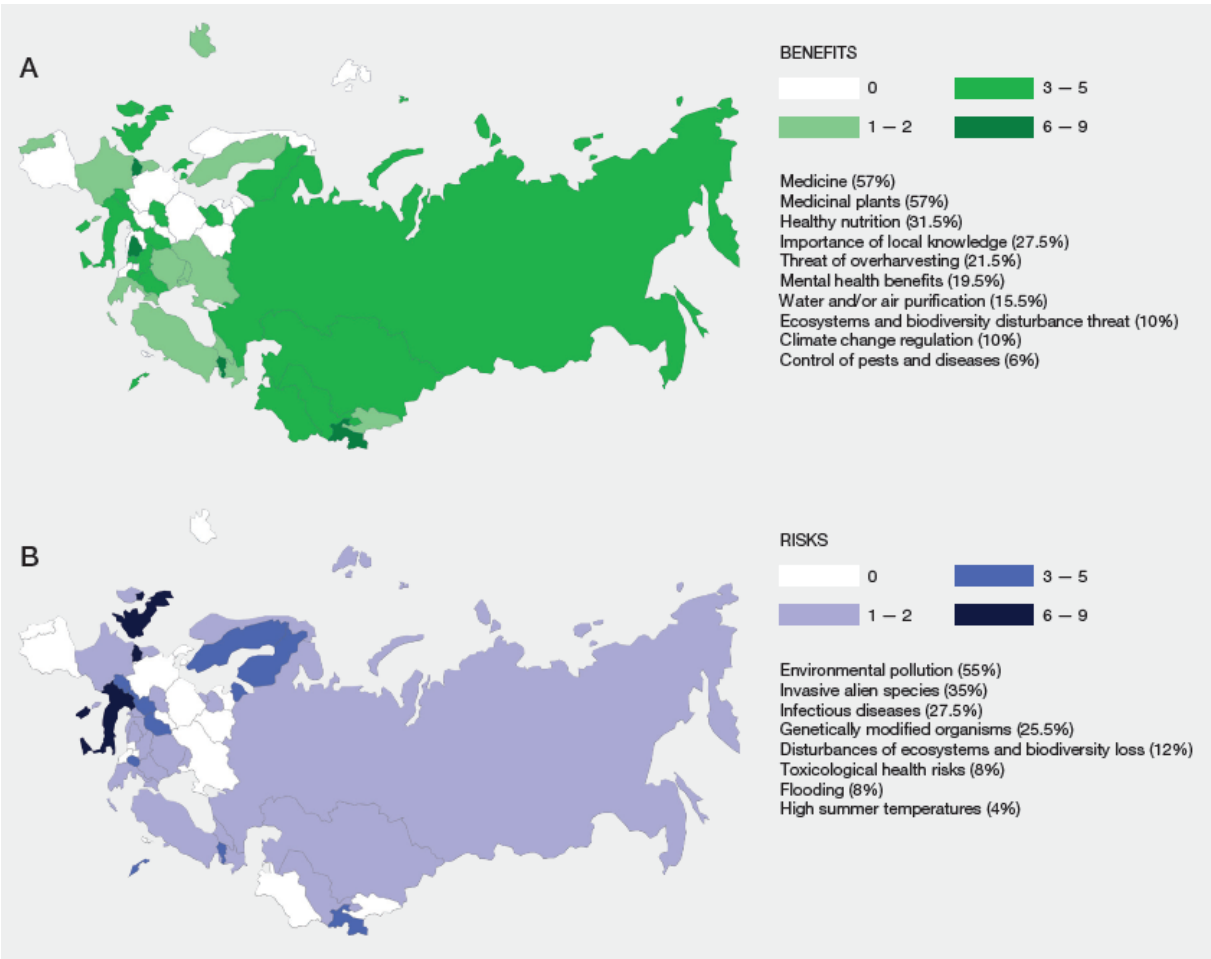


Figure 6.12: Number of different health-related benefits (A) and risks (B) addressed in national biodiversity strategies and action plans and national reports to the Convention on Biological Diversity. Furthermore, the insets indicate the percentage of countries in Europe and Central Asia mentioning specific health-related benefits and risks in these reports. Source: (CBD, 2016c), Chapter 2 electronic Appendix 2.8.

Most transport policies have a specific focus on global climate regulation and air pollution. A mandatory greenhouse gas reduction regime for international shipping was adopted by the International Maritime Organization (IMO, 2011). The current European Commission roadmap on transport, for example, follows a list of 40 initiatives, some of which have a direct effect on the environmental impacts of transport. In particular, key goals by 2050 include: a 60% cut in transport carbon emissions; 40% use of low carbon fuels in aviation; a 40% cut in shipping emissions; zero conventionally-fueled cars in cities; and a 50% shift of medium distance intercity passenger and freight journeys from road to rail and waterborne transport (European Commission, 2011c). Sustainable policies to reduce transport activity are usually local and diverse.

Finance is also a crucial service sector essential for achieving sustainable development. As highlighted by the overarching Goal 17 on “partnership for the goals”, “urgent action is needed to mobilize, redirect and unlock the transformative power of trillions of dollars of private resources to deliver on sustainable development objectives”.

33324 6.5.5.2 Governance modes and policy instruments

33325 The Convention on Biological Diversity reported, together with the World Health Organization, on the
 33326 state of knowledge on the interlinkages between biodiversity and human health (WHO & Secretariat
 33327 of the CBD, 2015), highlighting the emergence of vector-borne diseases in Europe and Central Asia and
 33328 other temperate areas. Flexible “integrated vector management” of vector-borne diseases has already
 33329 been successful in developing countries and such successful approaches can be taken as good
 33330 examples by policymakers in Europe and Central Asia. Integrated vector management is based on the
 33331 premise that effective control requires the collaboration of health, environment, and development
 33332 institutions and community participation rather than exclusive action by the health sector. Integrated
 33333 vector management is rarely achievable through small-scale intervention projects from actors outside
 33334 local communities. Effective governance and policy instruments in this sense link to international
 33335 initiatives and involve a strong participation of local communities (WHO & Secretariat of the CBD,
 33336 2015). In developed countries, health concerns are market drivers to consider when designing relevant
 33337 policy instruments. Different degrees of implementation of instruments and policy mixes can be
 33338 observed in the subregions of Europe and Central Asia (see synthesis **Table 6.11**).

33339 The role of consumer education is evident in the manifold eco-labeling and environmental certification
 33340 schemes that were created through a bottom-up process of public concern about biodiversity and
 33341 ecosystem services loss (e.g. the Forest Stewardship Council – FSC; the Marine Stewardship Council –
 33342 MSC; Rainforest Alliance and others). Eco-labelling and certification schemes are well implemented in
 33343 the European subregions (synthesis **Table 6.11**). Environmental certification is also a highly effective
 33344 tool in promoting sustainable ecotourism. Sustainable tourism, both in environmental and economic
 33345 terms, is achievable if regulators favor the access to biodiversity and other environmental resources
 33346 exclusively to businesses with track record of good environmental stewardship (TEEB, 2012). The
 33347 tourism sector is developing tools to evaluate specific risks associated with climate change, water
 33348 pollution, and unsustainable tourism practices (Patterson, Niccolucci, & Bastianoni, 2007), and to
 33349 adapt to these risks. Investments by public-private partnerships of tourism companies, governments
 33350 and NGOs to establishing and maintaining natural parks can be highly beneficial for biodiversity and
 33351 ecosystem services, supporting businesses and livelihoods (TEEB, 2012). Instead of viewing nature
 33352 conservation and the mainstreaming of biodiversity into sectoral policies as something for which we
 33353 have to sacrifice our wellbeing, perceiving nature as natural capital can help in the business world to
 33354 better consider it as one of society's important assets (Liu, Costanza, Farber, & Troy, 2010). This is also
 33355 true for retailers and consumers, with an increasing share of the latter looking for certified products.

33356 The European Union recognizes that social and environmental costs of transport are not fully borne by
 33357 transport users in European Union member States. Without policy intervention, transport users are
 33358 faced with incentives that may lead to uninformed travel decisions. The implementation of market-
 33359 based instruments to internalize the external costs of transport could inform efficient transport
 33360 pricing. This has been advocated by a series of European Commission policy documents, such as the
 33361 2011 White Paper on Transport, and the technical support study for policy analysis “IMPACT”: a
 33362 summary of the existing scientific and practitioner’s knowledge on “*internalization measures and*
 33363 *policies for all external cost of transport*” (Korzhenevych et al., 2014). If decision-makers would like to
 33364 improve the situation by promoting mainstreaming of biodiversity and nature’s contributions to
 33365 people, methodological guides to raise customers’ awareness of CO₂ emission levels are effective tools
 33366 that governments can provide and the business sector can implement (synthesis **Table 6.11**). One such
 33367 example is a guide provided by the French Ministry of the Environment (French Ministry of Ecology,
 33368 2012) and implemented by the French National Rail Company SNCF; another is the carbon offset
 33369 scheme implemented by the Portuguese National Airline Company TAP (Act Eco). Market-based and
 33370 financial instruments, such as carbon cap and trade schemes and carbon taxes, are effective at

33371 incentivizing simultaneously different initiatives towards reducing environmental impacts of the
 33372 transport sector (Flachsland, Brunner, Edenhofer, & Creutzig, 2011). Fuel taxes generate higher fuel
 33373 prices that stimulate the development of more fuel-efficient vehicles, reducing travelled distances,
 33374 vehicle ownership and per capita fuel expenditures (Goodwin, Dargay, & Vythoulkas, 2004; Litman,
 33375 2013; Pachauri et al., 2014).

33376 From the 1970s onwards, infrastructure development became increasingly unbundled through forms
 33377 of corporatization or privatization, spurring fragmentation and spatial inequality in many countries
 33378 (UN-HABITAT, 2009). Landscape fragmentation caused by land-use change is an important driver with
 33379 negative consequences for biodiversity and nature's contributions to people (Section 3.3.2; Sections
 33380 4.5 and 4.6). Transport planning and respective infrastructure development as an effect of meeting
 33381 projected transport demand has proved to be unsustainable and detrimental for biodiversity and the
 33382 environment (Banister, Anderton, Bonilla, Givoni, & Schwanen, 2011; Saleh & Sammer, 2009). More
 33383 effective policies have to be based on providing high quality public transport and coordinating various
 33384 land uses and transport planning. Regarding transport planning, effective regulatory instruments are
 33385 based on speed limit control (that can generate a 15% reduction in daily fuel consumption) (IEA, 2014;
 33386 Pachauri et al., 2014), carpool and telecommuting, car free days and efficient and clean cars. Fuel
 33387 economy (or CO₂ equivalent) standards are in force in most European and Central Asian countries.
 33388 These standards are considered as an effective policy (as part of a policy mix). Their effectiveness
 33389 mainly depends on their structure and level of stringency. The effective performance of single policy
 33390 instruments is highly context dependent (G. Santos, Behrendt, Maconi, Shirvani, & Teytelboym, 2010;
 33391 G. Santos, Behrendt, & Teytelboym, 2010). Feasible and applicable policy options depend on local
 33392 history and social culture, and have equity implications (Pachauri et al., 2014). Voluntary agreements
 33393 can also be effective such as the one implemented in 2013 by the International Maritime Organization,
 33394 making the "ship energy efficiency management plan" a mandatory measure for all ships (IMO, 2011).
 33395 Voluntary agreements are well implemented in Western Europe while under development or started
 33396 in the other subregions of Europe and Central Asia (synthesis **Table 6.11**). Effective policy intervention
 33397 can thus reduce transport activity growth and fossil fuel carbon intensity. Furthermore, it generates
 33398 diverse co-benefits such as improving biodiversity, urban living, energy security, and enhancing nature
 33399 contributions to people and environmental quality. Despite the fact that energy efficiency
 33400 improvements and a shift to hybrid vehicles are successful and important measures, reduction of
 33401 overall transport activity is essential to avoid rebound effects (Goodwin, 2012; IEA, 2014; I. Meyer,
 33402 Kaniovski, & Scheffran, 2012; Millard-Ball & Schipper, 2011; Pachauri et al., 2014; Schipper, 2011).

33403 The finance sector increasingly responds to the wishes of a new group of investors that are willing to
 33404 forego a fraction of their financial returns in exchange for positive social and environmental dividends.
 33405 Novel tools and approaches such as green bonds, sustainability stock indexes or novel interpretations
 33406 of pension funds' fiduciary duties to include social and environmental responsibilities are being used
 33407 to direct funds away from socially and environmentally damaging projects, towards projects that are
 33408 more sustainable (Paranque & Perez, 2016).

33409

33410 *6.5.5.3 Constraints and opportunities*

33411 Economic activities of the services sector can either damage biodiversity or help to conserve it.
 33412 Especially for the services sector, manifold opportunities arise when mainstreaming biodiversity and
 33413 nature's contributions to people in decision-making, notwithstanding the fact that biodiversity loss
 33414 and ecosystem degradation are accompanied by many constraints (synthesis **Table 6.11**, and text
 33415 below).

Biodiversity loss constrains businesses that seek to exploit medicinal and other properties of wild plants and animals (e.g. in the health sector) with repercussions on society at large. In a world of declining biodiversity, the public and private health sectors, including biotechnology development, need to plan for increased raw material costs that will bring along increasing health spending and spread of infectious diseases, exacerbated by poor water quality, degraded biodiversity and ecosystem services (TEEB, 2012). Therefore, in view of these developments, the health sector is important in mainstreaming biodiversity and ecosystem services into decision-making.

Climate change and water body pollution are strong drivers altering the availability of nature's contributions to people upon which the service sector relies. For example, the tourism sector is especially affected by the loss of natural assets such as coral reefs (TEEB, 2009a). There is a high risk, mainly related to land degradation, of losing ecotourism opportunities, recreational options, specific knowledge of managing certain ecosystems, and places that are spiritually important. Land-use regulations and policies can help preserving future options as well as cultural and heritage values related to the tourism sector (Scott, Hall, & Gössling, 2016).

Ultimately, the demand for ecosystem services is influenced by evolving consumer preferences and increasing consumers concerns about the environment (TEEB, 2012). An example is the decreasing acceptance of fur clothing in Europe and North America, with knock-on effects on both wild hunting and farming of animals for their fur (TEEB, 2012). Increasing awareness is influencing purchasing behavior: consumers are less willing to buy products from companies that disregard ethical sourcing practices and might be willing to pay more to compensate for negative impacts of consumption on biodiversity and ecosystem services.

The field of sustainable finance is still in its infancy, and faces some risks, such as greenwashing attempts. On the one hand, the financial sector heavily impacts nature and nature's contributions to people in cases where lenders or investors make their money available for projects that generate financial returns at the expense of social or environmental capital. On the other hand, the importance of the financial sector as a key player for moving towards sustainability is probably underappreciated, as the finance sector has the means to mobilize resources supporting the transition to sustainability when appropriately designed and implemented.

6.5.5.4 Summary

The services sector is a crucial sector for the realization of sustainable development pathways. Health, education, capacity-building and research are strong motivators for raising awareness of the importance of nature and nature's contributions to people for a good quality of life. While tourism, transport and finance continue to exert negative pressure on nature in many occasions, there are also many developments that can render these sectors more sustainable. Therefore, mainstreaming biodiversity and nature's contributions to people into decision-making and policymaking is especially important in these areas, calling for the most suitable instruments as part of the overall policy mix.

6.6 Mainstreaming biodiversity and nature's contributions to people

6.6.1 Three key steps of mainstreaming

Mainstreaming biodiversity and nature's contributions to people into national sectoral and cross-sectoral strategies, policies, plans and programmes at various spatial and temporal scales is a recognized and established objective in biodiversity policies (CBD, 2016a; European Commission, 2011a), yet lacks sufficient implementation in other sectors affecting nature. Given that at most 20%

of landscapes and seascapes will be protected if the Aichi Biodiversity Targets are achieved, our assessment shows that mainstreaming biodiversity and nature's contributions to people into private and public decision-making is one of the most important future tasks with regard to the remaining 80% (UNEP & UNECE, 2016). While many countries in Europe and Central Asia have, at least partially, integrated the concepts of biodiversity and nature's contributions to people into key policy documents and strategies, the uptake of these concepts, for example through concrete policy instruments, is rather weak (see Sections 6.3-6.5). Hence, there is room for improvement to protect nature effectively from the negative impacts of sectoral policies or private activities, such as consumption and production, and to support actively the integration of biodiversity and nature's contributions to people in decision-making and policymaking. The identified gaps between current practice and behavioural and policy changes needed to achieve future goals imply that existing policies and strategies are underperforming in terms of achieving the Aichi Biodiversity Targets and the Sustainable Development Goals.

This becomes even more obvious when considering future visions. In Chapter 5, four major pathways towards sustainable development have been identified (Chapter 5, Section 5.5.2). Mainstreaming by means of the three key steps listed below plays an important role in all four of these narratives. Most prominent across them is the use of awareness-raising tools, such as education and participation (Section 6.6.3). Further, a range of approaches for policy integration such as planning and environmental impact assessment is identified (Section 6.6.4). Concerning policy instruments, preferences for instrument categories differ across the mentioned narratives. While rights-based instruments and customary norms are neglected in most studies, legal, economic or social instruments are frequently applied and combined in policy mixes (Section 6.6.5). When comparing the current integration of biodiversity and nature's contributions to people into sector policies (see Sections 6.4-6.5) and potential future governance options aiming at sustainability transitions (Chapter 5, Section 5.5.2), there is a clear gap between the state of the art and desired pathways. However, it also means that there are many opportunities to close the gap by promoting more effective, efficient and equitable policies, where mainstreaming can play a prominent role.

Given the importance of biodiversity and nature's contributions to people for human wellbeing and a good quality of life our assessment provides opportunities to increase mainstreaming efforts by considering three key steps. The first step is **raising awareness** of human dependence on natural resources and nature's contributions to people (incl. provisioning of information, enhancing capacity building and strengthening participation). The second is **defining policy objectives** related to the ecological, economic and socio-cultural requirements for achieving a sustainable living. The third is **designing instruments and policy mixes** to support the implementation of mainstreaming of biodiversity and nature's contributions to people in public and private decision-making able to achieve the satisfaction of human needs (see Figure 6.13). After presenting a synthesis of the assessment of mainstreaming of biodiversity and nature's contributions to people across sectors in Europe and Central Asia, the remaining part of the chapter is structured based on these three steps.

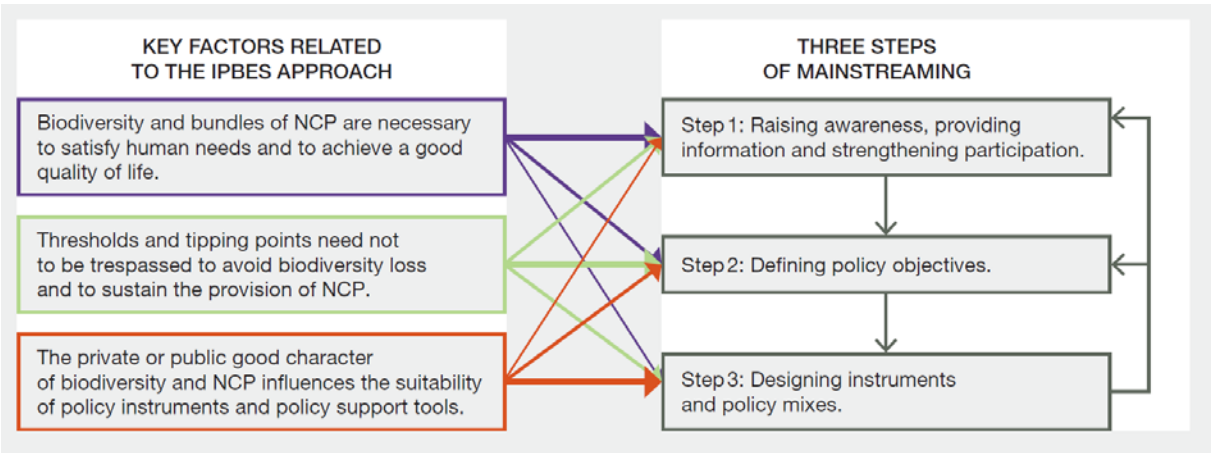


Figure 6.13: Three steps to link the IPBES approach to policy development and decision-making.
Source: Own representation.

6.6.2 Synthesis of the current state of mainstreaming in different sectors

Table 6.11 shows the current state of policy options and opportunities for mainstreaming biodiversity and nature’s contributions to people in Europe and Central Asia subregions. It synthesizes the sector analyses in Sections 6.4 and 6.5 and identifies promising options and opportunities across the different sectors. They are based on available literature in combination with expert judgments. Enhancing research and improving access to literature especially from Eastern European and Central Asian countries would allow for a more comprehensive assessment.

Table 6.11: Policy options and opportunities for mainstreaming biodiversity and nature’s contributions to people in Europe and Central Asia

Building on three key steps of mainstreaming, options and opportunities for mainstreaming are provided for seven policy and economic sectors. Although they have scope for improvement, legal and regulatory instruments are the most widely applied policy instrument category in all sectors and subregions, emphasizing their role as the backbone of policy mixes. Social and information-based instruments have been partly implemented in some subregions. There is also considerable scope for new or improved economic and financial instruments. Rights-based approaches and customary norms are the least developed and applied instrument category, indicating knowledge gaps and a lack of attention to indigenous and local knowledge and practices.

		Sectors	CONSERVATION				ENVIRONMENT ¹				AGRICULTURE			
STEPS	OPTIONS AND OPPORTUNITIES	Sub-regions	WE	CE	EE	CA	WE	CE	EE	CA	WE	CE	EE	CA
STEP 1: Raising awareness	Encourage education, joint learning and common understanding													
	Promote information sharing, transparency, knowledge management and training													
	Make trade-offs and tipping points visible at the relevant spatial scales													
	Encourage participation and dialogue among different actors													
	Make diverse values visible through national and business accounting													
	Mainstream recognition of need for profound societal transformation towards sustainability													
STEP 2: Defining policy objectives	Adopt and translate international and regional targets and standards into national and local strategies and action plans													
	Improve integration and coherence of legislation, sectoral policies and planning processes, to account for trade-offs and synergies													
	Develop context appropriate targets and objectives to stimulate positive change													
	Increase transparency and participation of a wide range of actors including indigenous peoples and local communities in decision making													
STEP 3: Designing instruments and policy mixes	Legal and regulatory instruments													
	Define and ensure property and access rights and responsibility													
	Set up, adjust and enforce legal and regulatory standards to sustain biodiversity and NCP													
	Set up areas to protect biodiversity and NCP													
	Economic and financial instruments													
	Phase out harmful subsidies		NA	NA	NA	NA								
	Tax and charge negative environmental impacts		NA	NA	NA	NA								
	Redistribute public revenues considering ecological objectives													
	Reward socio-economic activities delivering public goods													
	Secure conservation financing						NA	NA	NA	NA				
	Foster sustainable technological and social innovation													
	Social and information-based instruments													
	Promote eco-labelling and certification schemes and improve their transparency and accountability													
	Promote voluntary agreements and partnerships for responsible management, which include self-enforcement mechanisms													
	Promote sense of agency and efficacy through the enhancement of public participation													
	Support social norms that promote sustainable lifestyles and practices													
	Rights-based approaches and customary norms													
	Strengthen the use of indigenous and local knowledge and practices													
	Strengthen the consideration of cultural properties and heritage in protecting sites and landscapes						NA	NA	NA	NA				
	Strengthen the use of Social License to Operate or similar approaches to recognise the needs of indigenous peoples and local communities													

1. Include the following policy areas: Marine and freshwater quality and quantity, flood management, air and wider environmental pollution (including eutrophication and acidification), waste management, mitigation of and adaptation to climate change, soil management and land degradation. Options and opportunities in rows left blank have been covered by the other sectors, also in relation to their environmental outcomes.

WE = WESTERN EUROPE CE = CENTRAL EUROPE EE = EASTERN EUROPE CA = CENTRAL ASIA

■ EFFECTIVELY IMPLEMENTED ■ UNDER DEVELOPMENT OR STARTED □ NOT ASSESSED

■ IMPLEMENTED WITH SCOPE FOR IMPROVEMENT ■ NOT YET INITIATED NA = NOT APPLICABLE

Sectors		FORESTRY				FISHERIES				EXTRACTIVE & MANUFACTURING ²				SERVICES ³			
STEPS	OPTIONS AND OPPORTUNITIES	Sub-regions				WE	CE	EE	CA	WE	CE	EE	CA	WE	CE	EE	CA
STEP 1: Raising awareness	Encourage education, joint learning and common understanding																
	Promote information sharing, transparency, knowledge management and training																
	Make trade-offs and tipping points visible at the relevant spatial scales																
	Encourage participation and dialogue among different actors																
	Make diverse values visible through national and business accounting																
STEP 2: Defining policy objectives	Mainstream recognition of need for profound societal transformation towards sustainability																
	Adopt and translate international and regional targets and standards into national and local strategies and action plans																
	Improve integration and coherence of legislation, sectoral policies and planning processes, to account for trade-offs and synergies																
	Develop context appropriate targets and objectives to stimulate positive change																
STEP 3: Designing instruments and policy mixes	Increase transparency and participation of a wide range of actors including indigenous peoples and local communities in decision making																
	Legal and regulatory instruments																
	Define and ensure property and access rights and responsibility																
	Set up, adjust and enforce legal and regulatory standards to sustain biodiversity and NCP																
	Set up areas to protect biodiversity and NCP																
	Economic and financial instruments																
	Phase out harmful subsidies																
	Tax and charge negative environmental impacts																
	Redistribute public revenues considering ecological objectives																
	Reward socio-economic activities delivering public goods																
	Secure conservation financing																
	Foster sustainable technological and social innovation																
	Social and information-based instruments																
	Promote eco-labelling and certification schemes and improve their transparency and accountability																
	Promote voluntary agreements and partnerships for responsible management, which include self-enforcement mechanisms																
	Promote sense of agency and efficacy through the enhancement of public participation																
	Support social norms that promote sustainable lifestyles and practices																
	Rights-based approaches and customary norms																
	Strengthen the use of indigenous and local knowledge and practices																
	Strengthen the consideration of cultural properties and heritage in protecting sites and landscapes																
	Strengthen the use of Social License to Operate or similar approaches to recognise the needs of indigenous peoples and local communities																

2. Include the following policy areas: Energy, mining, manufacturing.
3. Include the following policy areas: Health, education and research, transport, tourism, finance.

WE - WESTERN EUROPE CE - CENTRAL EUROPE EE - EASTERN EUROPE CA - CENTRAL ASIA

■ EFFECTIVELY IMPLEMENTED ■ UNDER DEVELOPMENT OR STARTED ■ NOT ASSESSED
■ IMPLEMENTED WITH SCOPE FOR IMPROVEMENT ■ NOT YET INITIATED ■ NA - NOT APPLICABLE

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Some general conclusions can be drawn from the synthesis. While only a few options are effectively implemented, there is ample room for using opportunities along all three key steps and in all sectors. Specifically in the agricultural, conservation and services sectors, there are opportunities to increase the mainstreaming efforts in most subregions. While legal and regulatory instruments are implemented quite frequently, there are opportunities to enhance the application of other instruments. Several knowledge gaps exist, therefore, there is a need to further develop and deepen the assessment to remedy these gaps in the future. For more specific results regarding the three steps, see the detailed sector analyses in previous sections.

The findings in **Table 6.11** have similar conclusions to the fourth Global Biodiversity Outlook (Secretariat of the CBD, 2014), which summarizes the latest data on the status and trends of biodiversity and draws conclusions relevant to the further implementation of the Convention on Biological Diversity by assessing the progress towards meeting the 20 Aichi Biodiversity Targets. Public awareness concerning the importance of biodiversity and ecosystem services seems to be increasing (Target 1). Further, progress has been made in integrating biodiversity and ecosystem services in planning processes and national accounting (Target 2). However, there are still policy instruments in place that negatively affect the environment (Target 3), and even if resources are used more efficiently, it is unlikely that current production and consumption patterns are sustainable (Target 4). Therefore, mainstreaming biodiversity and ecosystem services across governments, society and economic sectors aims to address the underlying causes of biodiversity loss and environmental pressure. A crucial prerequisite - besides taking indigenous, local and scientific knowledge into account (Targets 18, 19) – is the implementation of standards concerning terminology, methods, data and reporting (Polasky, Tallis, & Reyers, 2015). National biodiversity strategies and action plans (Target 17) are important steps towards realizing the aims of the Strategic Plan for Biodiversity 2011-2020 at the national level, and to date most of the countries in Europe and Central Asia have compiled these plans. Integrating policy mixes is needed to address the holistic nature of socio-ecological systems. To be successful their implementation requires participatory planning, capacity building as well as mobilizing financial resources (Target 20). Based on the presented aspects current policies and initiatives can be assessed concerning their potential to reduce environmental pressures, and to capture the opportunities provided by biodiversity and ecosystem services, with the aim of enhancing benefits to all (Target 16). In a similar vein to the Global Biodiversity Outlook 4, this assessment shows that there are many options and opportunities for improvements. The following sections elaborate on the potential to accelerate progress in terms of mainstreaming of biodiversity and nature's contributions to people through various options and opportunities related to the three key steps of mainstreaming.

6.6.3 Raising awareness, providing information and strengthening participation

In the last decade substantial progress has been made in awareness raising based on (i) increasing knowledge in various scientific disciplines, (ii) disseminating results, and (iii) acknowledging their importance by governments, corporations and civil society (Kareiva, McNally, McCormick, Miller, & Ruckelshaus, 2015; Schröter et al., 2014). **Table 6.11** shows that awareness raising is implemented or under development in several sectors. However, not all available options are applied and there is scope for improvement, especially in Eastern Europe and Central Asia. Making the diverse values of nature's contributions to people visible, for example through accounting and valuation of ecosystem services, showing trade-offs and tipping points, as well as demonstrating the impact of changing production and consumption patterns are promising opportunities to raise public awareness, participation and transparency in the decision-making process. Communication, capacity building and public

33569 participation allow individuals, communities, firms, and governments to speak the same language and
 33570 to develop a common understanding of the environmental problems to be solved.

33571

33572 6.6.3.1 *Accounting, monitoring, footprints*

33573 Making the diverse values of biodiversity and nature's contributions to people visible is a crucial
 33574 prerequisite for mainstreaming. However, current economic indicators, such as gross domestic
 33575 product, are not able to reflect all dimensions of nature's contributions to people and good quality of
 33576 life (Dasgupta, 2009; Schleyer, Görg, Hauck, & Winkler, 2015). Therefore, further options are needed
 33577 to measure national welfare and sustainable development. Moving towards "measuring what we
 33578 manage" will facilitate the comparison between sectors as well as interaction and coordination among
 33579 them (TEEB, 2009b).

33580 In an attempt to take natural capital and the environment explicitly into account, the "System of
 33581 Environmental-Economic Accounting (SEEA) 2012-Central Framework" was developed as the first
 33582 international standard for environmental-economic accounting (United Nations, 2014). However, the
 33583 SEEA still falls short of providing actual total economic values. Besides, major current challenges in
 33584 environmental-economic accounting necessitate improvement of the database and development and
 33585 employment of extensive modelling to link services to the status of ecosystems and to the
 33586 beneficiaries.

33587 As a parallel initiative to the SEEA, the "Wealth Accounting and the Valuation of Ecosystem Services"
 33588 partnership (WAVES) aims to ensure that "*natural resources are mainstreamed into development
 33589 planning and national economic accounts*" by developing an ecosystem service accounting
 33590 methodology, establishing a "*global platform for training and knowledge sharing*" of stakeholders, and
 33591 building international consensus concerning natural capital accounting (WAVES, 2015, p. 18). These
 33592 initiatives point to moving beyond measuring economic activity and growth towards a broader concept
 33593 of social welfare comprising multiple dimensions and perspectives (Fleurbaey, 2009). Though
 33594 challenging, the opportunity exists to develop such a "*comprehensive methodological approach in
 33595 which biophysical, socio-cultural and monetary value domains can be explicitly considered and
 33596 integrated into decision making processes*" (Martín-López, Gómez-Baggethun, García-Llorente, &
 33597 Montes, 2014, p. 220). Promising attempts to develop experimental statistics along these lines include
 33598 the UK freshwater ecosystem assets and services accounts by (Khan & Din, 2015).

33599 Griggs and co-authors (2013, p. 306) suggest redefining the term sustainability as development that
 33600 meets the present needs while "*safeguarding Earth's life-support system, on which the welfare of
 33601 current and future generations depends*". A major challenge, when applying this definition to policy
 33602 making, is how to decide on an appropriate set of indicators of nature's contributions to people. To
 33603 fulfil Target 2 of the EU Biodiversity Strategy on maintaining ecosystems and their services, Action 5
 33604 requires member States to map and assess the state and economic value of ecosystems and ecosystem
 33605 services and to promote the integration of these values into accounting and reporting systems at
 33606 European Union and national level by 2020 (European Commission, 2011a). Achieving this target
 33607 requires the adaptation of multiple, biophysical and economic indicators relevant for each context
 33608 (Stiglitz, Sen, & Fitoussi, 2009). Here, ecosystem service standards that "*define terminology, acceptable
 33609 data and methods, and reporting requirements*" are a crucial prerequisite for mainstreaming
 33610 ecosystem services into public and private sectors (Polasky et al., 2015, p. 7356). Integrating the spatial
 33611 dimensions of ecosystem services within decision-making at different scales would raise awareness,
 33612 inform about the human dependence on diverse natural resources and enhance the recognition of
 33613 their values (UK NEA, 2011).

However, a key point of attention is the interaction between environmental accounting and policy. (Jakob & Edenhofer, 2015) conclude that, based on current green accounting systems, it is hardly possible to provide guidance for “real-world-policymaking”. They favour the option of a multi-dimensional concept of “welfare diagnostics”, where policy should focus on establishing “minimum thresholds” or “guardrails” for critical capital stocks that matter for welfare. (Oosterhuis, Esch, & Hoogervorst, 2016) name three opportunities to make environmental accounting a more effective tool for policy advice: (i) to improve coordination between providers and users of environmental accounts and cooperation with other organizations both collecting and using accounts; (ii) to enhance interpretation, assessment and policy evaluation based on the accounts, which requires a different set of expertise, including integrated valuation methods, policy instruments, indicator development and modelling, and that this role requires dedicated organizations; and (iii) to use multiple channels for presenting environmental accounts in a policy relevant way. However, for environmental accounting to make a substantial contribution to mainstreaming, there is an urgent need to develop the ways in which it can effectively inform policy making.

Box 6.8: Ecological footprint and interregional flows

The impact of production and trade on environment, ecosystems, and species has been demonstrated in various studies (see Chapter 2). The ecological footprint is an important tool which can be disaggregated into diverse footprints, e.g. for imports, exports and domestic production. This de-composition can be useful for policy makers in understanding the regional and international trade impact. Andersson & Lindroth (2001) list four different ways in which trade may affect ecological footprint: (i) a positive “allocation effect”, which reduces the ecological footprint as trade enables specialization of countries on products with higher domestic productivity; (ii) a negative “income effect”, which increases the ecological footprint as trade leads to higher domestic income, and thereby, consumption; (iii) a negative “rich-country-illusion effect”, which highlights the false impression in rich countries that their lifestyle is sustainable thanks to the possibility of importing bio- and sink-capacity from poorer countries; and (iv) a negative “terms-of-trade distortion effect”, which hints at the tendency of poorer countries to exploit natural resources beyond sustainable levels to avoid falling terms-of-trade during boom periods in world demand.

Lenzen and co-authors (Lenzen et al., 2012) argue that several species are in danger of extinction due to international trade along complex routes. The authors show evidence that international trade threatens 30% of global species. Furthermore, the consumption footprint of imported coffee, tea, sugar, textiles, fish and other manufactured items happens to be much larger abroad than in the country producing the good. Similarly, (Aşıcı & Acar, 2016) find that countries tend to relocate their ecological footprint as their income increases. The analysis was carried out for a panel of 116 countries by employing the production and import components of the ecological footprint data of the Global Footprint Network for the period 2004–2008. Within the income range of the selected countries, the import footprint was found to increase with income. Another study found that footprints of, for example, Turkish imports and exports increased with income during the period 1961–2008 (Acar & Aşıcı, 2017). This implies that countries tend to export the negative consequences of their consumption through imports rather than producing the environmentally harmful products domestically.

Weighell (Weighell, 2011) proposes biomass material flow analysis as a framework for policy implementation. His study shows that the UK’s biomass imports (except from Northern America) supply around 30% of the UK’s overseas land requirements, thereby leading to important environmental changes in these regions. The recognition of the original source of biomass helps to design targeted international policies in favour of biodiversity and nature’s contributions to people. In addition to supply-side concerns, demand-side policies have the potential to alter the impacts of biomass flows. For instance, a more efficient use of biomass especially through a reduction in waste along the food chain, can substantially impact national and international biomass demand (Weighell, 2011). As the material flow analysis helps to identify the imports, exports and domestic extraction of environmental resources, it is also utilized in relation to sustainable development in Switzerland. The Swiss government’s Sustainable Development Strategy (Swiss Federal Council, 2008) puts forward the Integrated Product Policy as a means to attain several sustainable development goals. For instance, sustainable material management targeting the reduction of consumption and environmental damage along with product quality improvements is part of the Integrated Product Policy.

End of Box 6.8

6.6.3.2 Sustainable consumption and production

Sustainable consumption and production is the result of actions taken by many different actors, from producers to final consumers (see **Figure 6.14**). The supply-chain perspective enables a comprehensive view on production and consumption, and provides information on relevant relations and possible opportunities for mainstreaming actions. The United Nations Environment Programme’s sustainable consumption and production clearinghouse shows 149 sustainable consumption and production initiatives in Europe and Central Asia, many of which contribute to reducing pressures on biodiversity and ecosystem services as they focus on agri-food, chemicals, mining, waste, building and construction, energy, manufacturing and water. Several projects bring in the supply-chain perspective through labelling, value chains and fair trade, and in this way contribute to a global perspective on sustainable consumption and production (Leadley et al., 2014; Sustainable Consumption and Production Clearinghouse, 2017). Currently policies seem to focus predominantly on the production side, while consumer-oriented policies are applied less frequently and mostly limited to information and nudging strategies.

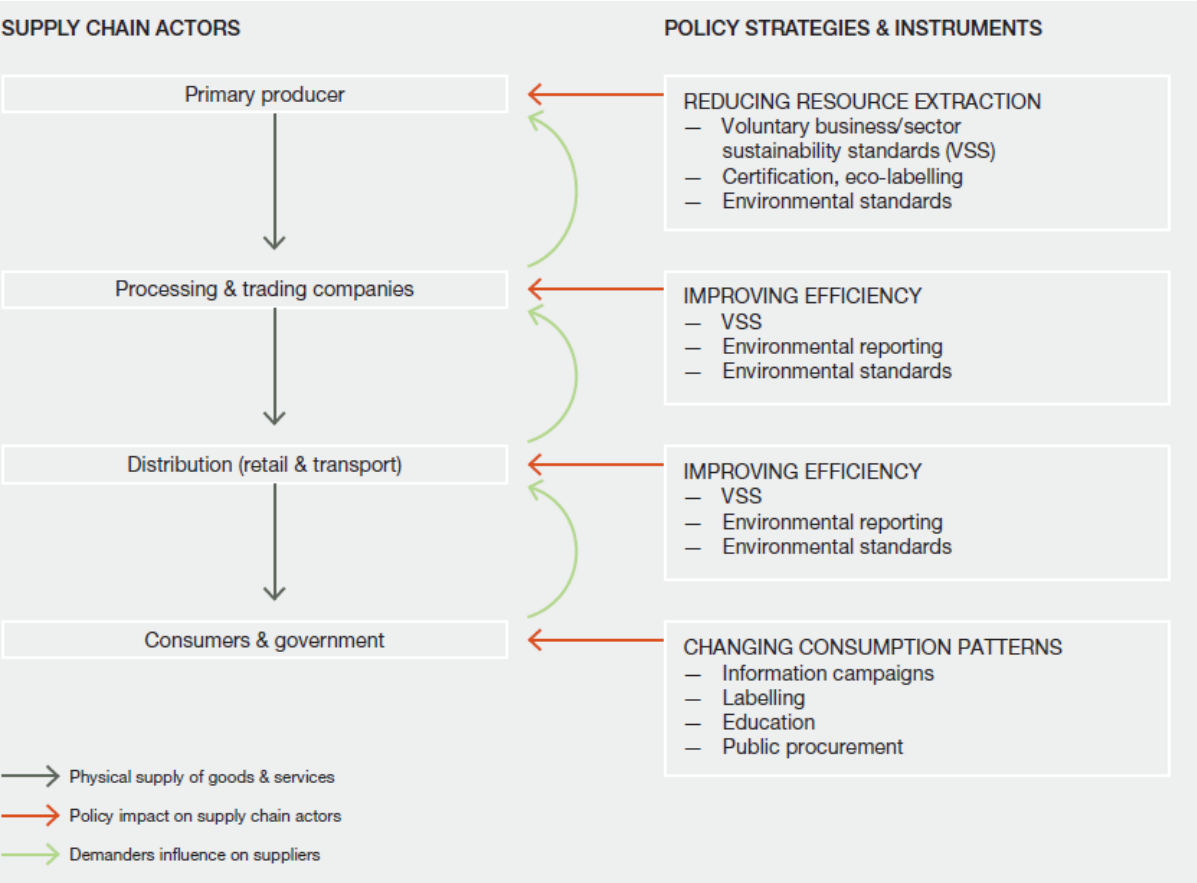


Figure 6.14: Policy options to reduce environmental impact on consumption and production. Source: adapted from (van Oorschot, Rood, Vixseboxse, Wilting, & van der Esch, 2012).

The explicit aim of Sustainable Development Goal number 12 is to ensure sustainable consumption and production patterns, where developed countries should take the lead (United Nations, 2015). For countries in Europe and Central Asia, this implies contributing their fair share to the global challenge

of staying within safe ecological limits. In evaluating current policies and initiatives a differentiation can be made between sustainable consumption and production policies which aim (i) at reducing pressures on biodiversity and ecosystem services and (ii) at capturing the opportunities provided by natural capital and ecosystem services.

Concerning the first aim, options to reduce environmental impact or pressure can be identified by the so-called IPAT identity (IPCC, 2000): $\text{Impact} = \text{Population} \times \text{Affluence} \times \text{Technology}$, where affluence can be approximated by production and consumption. The European Environment Agency (EEA, 2013a) identified three main environmental pressure types: material extraction, greenhouse gas emissions and air emissions. Main contributors to these impacts are agriculture and food products, forestry and fibre products, the electricity industry, water services, construction, transportation services, and basic manufacturing industries such as refinery, chemical products and basic metals; in the future possibly also bio-energy production. Food and lodging, housing and infrastructure, and mobility contribute most to the consumers' part.

Drawing on global environmental assessments (OECD, 2012b; UNEP & UNECE, 2016) five generalized types of options can be identified along the supply chain to reduce the main negative impacts on biodiversity and nature's contributions to people:

1. *Increase resource efficiency, including circular resource use (production)*
2. *Enhance sustainable resource production (production)*
3. *Design products with cradle-to-cradle-approach (production)*
4. *Promote consumption patterns with less environmental impacts (consumption)*
5. *Reduce waste at different stages (production & consumption)*

These complementary strategies for reducing the impacts of consumption and production seem to fall within the paradigm of "sustainable growth", considered an oxymoron by many (Daly & Townsend, 1993). Options for reducing consumption are worked out in Steady-State Economics (Daly, 1996), New Economics of Prosperity (Jackson, 2009; NEF, 2009; Schor, 2011); and Degrowth (Kallis, Kerschner, & Martinez-Alier, 2012; Latouche, 2009) (see Chapter 4).

Sustainable consumption and production policies in Europe and Central Asia have so far focused (i) on the contribution of the United Nations sustainable consumption and production 10-year framework, and (ii) on resource efficiency as part of competitiveness and European Union green economy strategy. However, beyond the European Union biodiversity strategy, there are promising opportunities for raising awareness of natural capital and nature's contributions in consumption and production policies in order to mainstream biodiversity and ecosystem services.

6.6.3.3 *Communication, capacity building and public participation*

In recent decades, large efforts have been made to raise awareness and to integrate stakeholders and the wider public into the governance of nature's contributions to people, for example through public debate, communication and knowledge sharing as well as public participation, organizational and individual learning and capacity building. Although these efforts have led to substantial progress, there are still significant opportunities to further harness the support of a wide range of actors to raise the awareness of the need for mainstreaming (Korn, Schliep, & Eppe, 2004) (**Table 6.11**). These opportunities are in line with Goal 17 of the Sustainable Development Goals, which calls to "revitalize the global partnership for sustainable development"; and Goal 16, aiming to "provide access to justice for all and build effective, accountable and inclusive institutions at all levels". Further, they are directly related to Strategic Goal E of the Strategic Plan for Biodiversity 2011-2020, namely to "enhance

implementation through participatory planning, knowledge management and capacity building” (Aichi Biodiversity Targets 17-20). Communication, capacity building and public participation, while all playing different roles in this endeavour, are intricately linked. For example, public engagement and participation can facilitate a broader understanding of nature’s contributions to people for all actors involved, but also lead to greater acceptance, legitimacy and long-term efficiency of the outcome of the process (Blackstock, 2017; J. C. Young et al., 2013). Participation can also help to build the capacity of civil society to engage in governance processes (Jones-Walters & Çil, 2011; Kouplevatskaya-Yunusova, 2005).

However, to make effective use of these opportunities, one needs to know how the concepts of ecosystem services and nature’s contributions to people are understood and used by stakeholders and the wider public. Essentially, this equates to the very wide-ranging and challenging question of how people understand their relationship with nature (Flint, Kunze, Muhar, Yoshida, & Penker, 2013). Especially the notion of ecosystem services (as well as cognate notions such as “natural capital”, (Costanza & Daly, 1992)), bear the inherent risk of “crowding out” intrinsic ideas of values (Flint et al., 2013; Setten, Stenseke, & Moen, 2012). In addition, as with other specialist concepts such as biodiversity (Buijs, Fischer, Rink, & Young, 2008; A. Fischer & Young, 2007) or climate change (A. Fischer et al., 2012), the population is likely to have a rough understanding of the phenomena captured, even though it might not be familiar with the exact terminology (Lock & Cole, 2011). The use of a streamlined terminology might thus unduly simplify or restrict the more complex notions held by other actors. Such externally-defined frameworks are also prone to obscuring or omitting emotional and experiential dimensions of understanding nature’s contributions to people. (Kassam, Bulbulshoev, & Ruelle, 2011; Verma, van der Wal, & Fischer, 2015; K. Williams & Harvey, 2001).

These considerations notwithstanding, a substantial number of studies, usually framed with reference to specific ecosystems in Western and Central Europe, have assessed people’s awareness of ecosystem services and perceptions of their relative importance (Agbenyega, Burgess, Cook, & Morris, 2009; Hartel et al., 2014; López-Santiago et al., 2014; Martin-Lopez et al., 2012; Plieninger, Dijks, Oteros-Rozas, & Bieling, 2013). Generally, such studies seem to reveal widespread appreciation of nature’s contributions to people. While detailed findings vary a lot between studies (Agbenyega et al., 2009; Martin-Lopez et al., 2012), these differences are likely related to the socio-ecological context and framing of the evaluation. In addition, people’s perceptions of ecosystem services vary with their backgrounds, roles, identities and experiences and are related to socio-demographic variables (A. Fischer & Eastwood, 2016; Kassam et al., 2011; López-Santiago et al., 2014; Martin-Lopez et al., 2012; J. C. Young et al., 2013). Underpinning these are their broader understandings of, and relationships with, nature (Buijs, 2009; López-Santiago et al., 2014), and wider discursive contexts (Kull, de Sartre, & Castro-Larranaga, 2015). The main implication of much of this literature is, as (Lock & Cole, 2011, p. 8) put it, that “[greater knowledge exchange around ecosystems services is required: efforts to enhance public knowledge and understanding [...] may improve public acceptability of interventions [...]. In turn, such interventions could be more sensitively designed when based on a better understanding of the ways in which the public value these services and spaces (i.e. when decisions are made using both lay and expert knowledge).” (see also a global literature review by (Sterling et al., 2017)).

Such participation and joint learning has been increasing over recent decades, and the scientific literature on these issues is burgeoning. There has been widespread uptake of approaches such as co-management, co-governance and other collaborative arrangements (Ansell & Gash, 2008) (Section 6.4.2), as well as stakeholder participation in environmental decision-making (J. C. Young et al., 2013) in many places across Europe and Central Asia. However, there is still significant scope for an expansion of these approaches across all relevant sectors, as, for example, (J. C. Young et al., 2007) have pointed out for Central and Eastern Europe (see also)(Griewald, Clemens, Kamp, Gladun, & Hölzel, 2017;

Stringer & Paavola, 2013; Ulybina, 2014). Stakeholder participation, besides being a policy instrument in itself (Section 6.2), can be fruitfully combined with a wide range of other policy instruments, and is, in fact, already an integral part of some pieces of legislation such as the European Union Water Framework Directive (Sections 6.3 and 6.4) (Blackstock, Waylen, Dunglinson, & Marshall, 2012). But even where no explicit provision for the use of participatory methods exists, participation and joint learning can, in many cases, improve the governance of biodiversity and nature's contributions to people (Jones-Walters & Çil, 2011).

For example, in some areas in Germany, NGOs and civil society have relatively recently gained influence in decision-making processes in the forestry sector, which previously only involved traditional forestry actors (Maier, Lindner, & Winkel, 2014). Conversely, the process of establishing and drawing up management plans for designated areas such as marine protected areas (Ruiz-Frau et al., 2015), Biosphere Reserves under the United Nations Educational, Scientific and Cultural Organization (Bridgewater & Babin, 2017) or European Union Natura 2000 sites (Brescancin, Dobšínská, De Meo, Šálka, & Paletto, 2017; J. C. Young et al., 2013) can also be an opportunity for joint learning and participatory decision-making. Studies show the main effect of stakeholder participation in processes around three Natura 2000 sites in Scotland was an increase in trust (J. C. Young et al., 2013). Their findings also highlight that local views have to be taken seriously, rather than their participation being just a token exercise. As a result perspectives that deprioritize ecosystem services might also have to be accepted (Maier et al., 2014). Institutional processes need to be designed such that there are clear ways in which the outcomes of participatory activities can be fed into decision-making (Kouplevatskaya-Yunusova, 2005; Reed, 2008). Participatory approaches also run the risk of privileging certain perspectives over others – often those by “*high income, well-educated and time-rich*” stakeholders (Blackstock, 2017, p. 343) or those that use specialist language and knowledge to dominate the decision-making process (Maier et al., 2014). Cultural differences in terms of discussion styles and willingness to allow conflictive encounters might also act as barriers to successful participatory processes (Kouplevatskaya-Yunusova, 2005). This is particularly true for countries in Eastern Europe and Central Asia that lack experience in deliberative democracy and collaborative decision-making. Non-state actors are keen to participate, but their transformative capacity is often severely constrained (Ulybina, 2014). Furthermore, attempts to increase participation in policy development often result in the re-appropriation of power by traditionally powerful stakeholders (Kouplevatskaya-Yunusova, 2005).

Finally, repeated stakeholder involvement – especially if outcomes and actual policy uptake are unclear – can lead to stakeholder fatigue and withdrawal (Blackstock, 2017; Reed, 2008). Far from being a panacea (Blanchard, 2015), participation is thus a social process that has risks and costs as well as benefits. Not least because of these challenges, participatory approaches require skilled facilitators (Blackstock, 2017; Reed, 2008), drawing on the large amount of collective experience to further enhance the mainstreaming of biodiversity and nature's contribution to people.

6.6.4 Defining policy objectives

The ecosystem service concept and the further developed concept of nature's contributions to people offer a framework to identify policy objectives and contribute to identifying limits for trading off one service for another, beyond which intended substitution can lead to catastrophic results (Bastian, Corti, & Lebboroni, 2007; Jax, 2014; Mace et al., 2014; Rockström et al., 2009; Simoncini, 2009). Given that the same ecosystem processes and components often provide bundles of diverse services simultaneously, a comprehensive assessment of the ecological, economic and social conditions is

needed. Policy integration and spatial planning are two important options to consider synergies and trade-offs when defining policy objectives.

6.6.4.1 Policy integration

The status of biodiversity and the quality and quantity of ecosystem services are often determined by economic, trade, agricultural, forestry and other sectors (MA, 2005). Improved coordination across sectors, actors and scales offers opportunities for effective action to address problems related to biodiversity and ecosystem services for human well-being. Although this has been recognized by the European Union for more than a decade, only few countries make intensive efforts to develop integration strategies (EEA, 2005). Thus, mainstreaming biodiversity and the multiple values of nature's contributions to people remains an essential task (MA, 2005b; PBL, 2014; UNEP, 2011a). In this context, identifying synergies to conserve and enhance multiple services is as important as recognizing potential trade-offs between ecosystem services (Vira, Elliott, Fortnam, & Wilks, 2011).

The identification and analysis of relationships among multiple levels of socio-ecological systems at different spatial and temporal scales is a core challenge to achieve sustainability (Ostrom, 2009). This includes the need to recognize the holistic nature of socio-ecological systems. More specifically, integrated policies have to be designed and implemented, requiring policy integration within and across different economic, policy and societal sectors. Coordination needs to be improved among international institutions and across decision-making levels, taking due account of scientific insights, local communities' and indigenous peoples' knowledge, as well as different socio-cultural contexts and related value systems. A core task in this context is integrating biodiversity and ecosystem services into poverty reduction and development strategies. Drawing on the sector policy analyses earlier in this chapter, conflicts of forestry with other sector policies have been highlighted as one of the major challenges for the integration of nature conservation into forest policy (Winkel et al., 2015). The relation between the forestry sector and Sami reindeer herders in Sweden can be seen as an example, where neglecting the holistic character (including biological, geographical and climatic, as well as linguistic, socio-economic and management issues) and a missing mutual understanding can aggravate conflicting situations (Kitti, Gunsley, & Forbes, 2006; Roturier & Roué, 2009). Improving information tools for decision-makers is one important strategy to follow.

Integrated policies are necessary to consider consumption and production processes at different scales, at local, regional and national levels, and relating to impacts displaced to foreign countries (see Section 6.6.2.1). Some examples are (i) land-use policies to enforce and regulate transnational land acquisitions ("land-grabbing") (Rulli, Savioli, & D'Odorico, 2013); (ii) regulation and monitoring of conflict-free mineral trade (S. B. Young, Zhe, & Dias, 2014); and (iii) the adoption of "*principles for responsible agro-investment*" (Deininger & Byerlee, 2011).

Besides individual policy instruments and their interaction in policy mixes, which are dealt with in Section 6.6.5 below, there are a number of policy-support tools specifically dedicated to checking for consistency between objectives, instruments and potentially adverse impacts from one to another strategy, policy, programme or individual project (see IPBES web portal on policy support tools: IPBES, 2017). Strategic environmental assessment (SEA) and environmental impact assessment (EIA) provide promising options to improve mainstreaming attention for biodiversity and ecosystem services across a wider range of sectors, beyond environment and conservation (Geneletti, 2013; Helming, Diehl, Geneletti, & Wiggering, 2013; Lamorgese & Geneletti, 2013).

Box 6.9: Policy support tools to integrate across sectors and scales: strategic environmental assessment and environmental impact assessment

33870 As a key instrument to ensure good quality of policies, planning and programs, strategic environmental assessment
33871 (SEA) has been established in most countries, for example at European Union level through directive 2001/42/EC.
33872 In addition, environmental impact assessment (EIA, 2014/52/European Union) performs an appraisal of the effects
33873 of environmentally relevant public or private projects. Both assessment tools take account of spatial and temporal
33874 scales, and provide options for conceptualizing the diverse values of biodiversity. They have a great potential to
33875 mainstream biodiversity and nature's contributions to people by applying assessment, decision and monitoring
33876 criteria, and they can highlight development opportunities and potentially warn about negative biodiversity and
33877 nature's contributions to people impacts (Geneletti, 2013). Providing a process-oriented assessment framework,
33878 strategic environmental assessment could contribute to evaluation of the coherence, synergies and conflicts
33879 between different policy sectors using biodiversity and ecosystem services standards and indicators to enable a
33880 multidimensional and multi-scale trade-off analysis. Another challenge consists in considering biodiversity and
33881 nature's contributions to people in a transboundary context. Here, the Espoo Convention on Environmental Impact
33882 Assessment in a Transboundary Context (Glasson, Therivel, & Chadwick, 2013; OECD, 2005; Espoo Convention:
33883 United Nations, 1991) obliges the 45 ratifying countries to perform an environmental impact assessment of
33884 proposed activities on the environment at an early stage of planning. States are obliged to inform and consult
33885 others on all major projects that might have a significant adverse environmental impact across boundaries. The
33886 integration of biodiversity and ecosystem services in such mutual assessment and information processes could
33887 greatly contribute to set standards for critical thresholds or tipping points, delineate impact areas and identify
33888 appropriate instruments and actions to avoid environmental degradation.

33889 Strategic environmental assessment and environmental impact assessment frameworks could provide suitable
33890 instruments to assess and improve the coherence between different policy sectors and to create synergies
33891 considering their direct or indirect impacts on terrestrial, freshwater, marine and coastal systems. Further, they
33892 could promote and integrate stakeholder views on the importance of biodiversity and nature's contributions to
33893 people (Slootweg, Rajvanshi, Mathur, & Kolhoff, 2009), and may be combined with information tools and scenario
33894 modelling (see Chapter 5) to provide tailored information for different types of actors. However, formal and
33895 informal participation needs to be implemented more concisely. Adapted participatory instruments could help to
33896 consider different socio-cultural contexts of public and private decision-making in planning and natural resource
33897 management. However, the effectiveness of strategic environmental assessment to enhance the consideration of
33898 environmental aspects in planning is still debated and seems to be context dependent (Cashmore, Richardson,
33899 Hilding-Rydevik, & Emmelin, 2010; Hilding-Rydevik & Bjarnadóttir, 2007) (see Section 6.6.1). Further, caution is
33900 warranted regarding who assesses policies or projects for whom. As holds for any assessment, independence of
33901 those who assess from those who finance, or investors whose projects are being assessed, as well as transparency,
33902 legitimacy and credibility, are crucial for the outcomes to be widely accepted (Lebel, 2006).

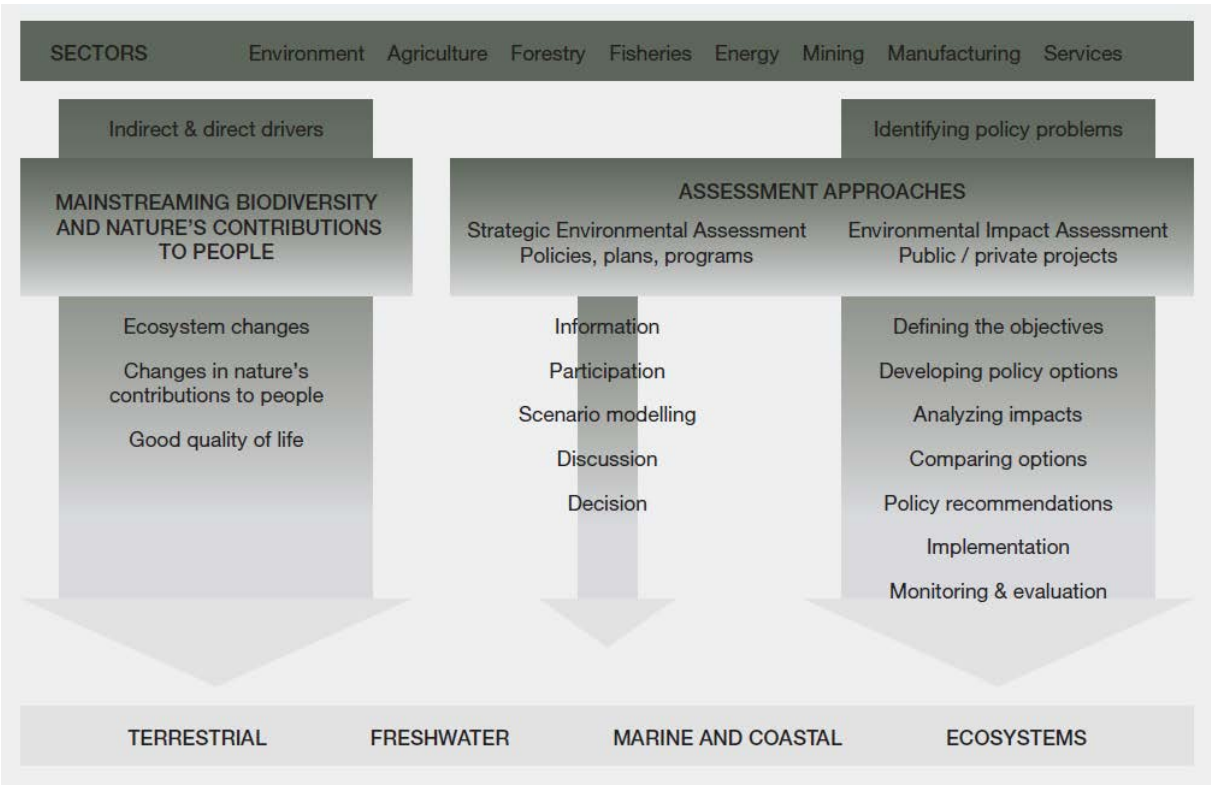


Figure 6.15: Mainstreaming biodiversity and ecosystem services in SEA and EIA. Source: Own representation.

End of Box 6.9

6.6.4.2 Integration through spatial planning

Spatial planning is a “[...] key instrument for establishing long-term, sustainable frameworks for social, territorial and economic development both within and between countries. Its primary role is to enhance the integration between sectors such as housing, transport, energy and industry, and to improve national and local systems of urban and rural development, also taking into account environmental considerations. [...]” (UNECE, 2008, p. vii). It usually combines legal and regulatory instruments with more informal instruments. These can be complemented by financial instruments such as the common agricultural policy (CAP), rural development policy⁴³ and LEADER⁴⁴ (see Section 6.4). Spatial planning can both positively and negatively influence the conservation and sustainable use of biodiversity and nature’s contributions to people (von Haaren, Albert, & Galler, 2016), the key opportunity being its integrative potential through providing a cross-disciplinary view towards more sustainable development (Goodstadt et al., 2012; Niemelä et al., 2010; UNECE, 2008). It is increasingly recognized that a social-ecological perspective is key in effective planning due to its potential to include resilience into spatial recommendations (Folke, 2006) and thus to identify and address impacts and trade-offs of policy options and ensure informed decisions for sustainable development (Chan, Shaw, Cameron, Underwood, & Daily, 2006; Goodstadt et al., 2012; Zisenis, 2009).

If implemented without consideration of social-ecological implications, planning development can have a substantial negative impact on biodiversity and nature’s contributions to people, for example

⁴³ www.europarl.europa.eu/atyourservice/en/displayFtu.html?ftuid=FTU_5.2.6.html
⁴⁴ <https://enrd.ec.europa.eu/en/leader>

if ecosystem processes and functions are destroyed, landscapes are fragmented or soils are sealed (Forman & Collinge, 1997; Opdam, Foppen, & Vos, 2002; Scolozzi, Morri, & Santolini, 2012). Conversely, a well-balanced social-ecological spatial planning framework positively affects the provision of biodiversity and nature's contributions to people and subsequently quality of life, for example by reducing the ecological footprint of cities; enhancing accessibility to, and the cooling effect of, green spaces in urban agglomerations; and overcoming trade-offs from single-sector focused decisions (Bateman et al., 2013; TEEB, 2011a). A case in point are urban areas, which illustrate contrasting urbanization trends and examples of emerging science-policy linkages for improving urban landscapes for human health and quality of life. Cities increasingly engage in protecting and enhancing the capacity of their ecosystems to meet urban resident needs, for example through novel management systems in Stockholm, civic engagement in Berlin, and a shift towards nature-based flood mitigation in Rotterdam (Schewenius, McPhearson, & Elmqvist, 2014). Urban planning has particular responsibilities to ensure biodiversity protection and nature's contributions to people delivery today and in the future to enhance the quality of life of an increasing number of urban dwellers (Gómez-Baggethun & Barton, 2013). It can help to avoid costs in nature's contributions to people impairments and identifying safe-to-fail strategies or probes that will allow the nature of emergent possibilities to become more visible (Ahern, Cilliers, & Niemelä, 2014; Grêt-Regamey, Celio, Klein, & Wissen Hayek, 2013; Niemelä et al., 2010). Concepts such as green infrastructure help to identify and communicate the benefits which conserving and sustainably using biodiversity and nature's contributions to people have for nature and human well-being (Tzoulas et al., 2007) (see Chapter 3). As shown in Section 6.3.2 marine spatial planning has also proved successful in considering biodiversity and nature's contributions to people (Flannery & Ó Cinnéide, 2008).

Targeted spatial planning that integrates across sectors and scales can substantially enhance the conservation and sustainable use of biodiversity and nature's contributions to people (Bateman et al., 2013). The particular opportunity for spatial planning exists in its capacity to make explicit, and support the integration of, diverse interests and policy fields. Spatial planning addresses multiple scales, incorporating the local and regional scale, the different policy scales as well as sectoral and infrastructural aspects. Hierarchies and the level of detail at which topics are addressed, as well as institutional responsibilities, vary considerably among countries (OECD, 2001). Spatial planning has the capacity to safeguard sensitive areas, enhancing the state of ecosystems, minimizing current and potential future impacts, and identifying synergistic land use options. For example, Swedish forest policy has gradually picked up science-based biodiversity conservation in line with the Convention of Biodiversity (Angelstam et al., 2011). Informed planning can furthermore enhance the engagement and experience of nature among citizens, facilitate public participation, enhance environmental behaviour and stewardship, and provide the basis for targeted investments in nature's contributions to people, for example by designating specific areas for results-oriented agri-environmental measures (Beatley & London, 2011; Hartig, Kaiser, & Bowler, 2001; Wells & Lekies, 2006).

Important challenges remain for an enhanced consideration of biodiversity and nature's contributions to people in spatial planning in Europe and Central Asia (EEA, 2009). The sectoral nature of policies leads to fragmented spatial strategies that fall short of a comprehensive consideration of environmental issues. Spatial proposals to improve biodiversity and nature's contributions to people need to be developed and better implemented. Delivery mechanisms for proposed actions are poor, since separate actors often administer planning and implementation. The uptake of environmental considerations is further complicated by limitations in political support and financial resources, spatial misfits between planning constituencies and ecosystems (Trepel, 2010), and distributed responsibilities in federal systems (von Haaren & Reich, 2006).

If the consideration of biodiversity and nature's contributions to people is to be enhanced in spatial planning, a multi-scale approach needs to be applied to decision-making and to ensure that public interests and the benefits provided by functioning ecosystems are considered in decision-making (TEEB, 2011a). Trade-offs between different contributions by nature to people, as well as between biodiversity and nature's contributions to people, need to be accounted for in decision-making about preferable spatial planning strategies and implementation actions. Key issues that would benefit from a better consideration of biodiversity and nature's contributions to people are, among others, human health and quality of life, issues of water and energy security, climate adaptation and mitigation, and flood control, recreation and locational quality (cf. Chapters 2, 4, 5). Several studies illustrate options for better integration of biodiversity and nature's contributions to people in planning, for example landscape planning (Albert, Galler, et al., 2016; Albert, Aronson, Fürst, & Opdam, 2014; van Oudenhoven, Petz, Alkemade, Hein, & de Groot, 2012), urban planning and economic valuation (Gómez-Baggethun & Barton, 2013; Schewenius et al., 2014), or Strategic Environmental Assessment (Geneletti, 2013). Successful examples for integrating biodiversity and nature's contributions to people in spatial planning include river restoration in Vitoria-Gasteiz (Kopperoinen, 2015) and protected area management in Doñana, Spain (Palomo, Martin-Lopez, Lopez-Santiago, & Montes, 2011).

Three methodological challenges for a systematic assessment can be pointed out: (i) an assigning problem related to difficulties in detecting cause-effect relations between planning measures and outcomes; (ii) an indicator problem because it is not possible to quantitatively measure the qualitative impact; and (iii) a time framing problem due to the long time span between implementation and impact of a measure (Fürst, 2005). Knowledge gaps exist concerning a comparative overview of spatial planning throughout Europe and Central Asia. Comparative studies on spatial planning and its effectiveness across such a diverse group of countries is particularly challenging: most literature on planning is only available in national languages and often differences exist between planning as described in the legislation, and applied practices. Further knowledge is needed on how particular planning modes and planning instruments affect biodiversity and nature's contributions to people and how respective information could best be integrated and communicated in planning processes so that it is understood and appropriately considered in decision-making (Albert, Galler, et al., 2016; de Groot, Alkemade, Braat, Hein, & Willemen, 2010).

6.6.5 Designing, implementing and assessing instruments and policy mixes

Nature contributes in diverse ways to human well-being. Depending on the character as private or public goods or services, various institutional failures concerning their provision can lead to biodiversity loss and ecosystem degradation (TEEB, 2010). Mainstreaming can contribute to overcoming these failures by designing and implementing different policy instruments and tools (Costanza et al., 2014; Kenter et al., 2015; Muradian & Rival, 2012; Parks & Gowdy, 2013). The assessment of specific policy instruments in the realm of biodiversity and nature's contributions to people is, however, a major challenge. On the one hand it comprises quite heterogeneous and complex systems involving multiple actors and governance levels (Buizer et al., 2011; Paloniemi et al., 2015). On the other hand, instruments have to be applied and assessed under uncertainty due to severe information gaps (e.g., concerning scientific knowledge about ecological production functions or bio-physical trade-offs). Further, different future pathways (see Chapter 5) often call for a policy mix embedded in specific institutional settings, which makes it difficult to assess them in an isolated way. Such a policy mix could start top-down with the design of regulatory instruments based on socio-ecological indicators in the proximity of tipping points, in order to assure a minimum sustainable provision of nature's contributions to people. Beyond this point, ecosystem service delivery could be

further enhanced by applying economic, financial and information-based instruments, including bottom-up approaches. By adopting this architecture for policy design, it is possible to envisage promising opportunities to enable a re-thinking of the decision-making process particularly for policies envisioning specific pathways.

6.6.5.1 Legal and regulatory instruments

In principle, regulatory instruments can contribute to all policy strategies, including mainstreaming of biodiversity and nature's contributions to people, and **Table 6.11** shows that they are widely applied in Europe and Central Asia. However, a balancing of practical flexibility and legal certainty in the design and implementation of these instruments is necessary to ensure their effectiveness and efficiency (Garmestani, Allen, & Benson, 2013; IPBES, 2016b). Recent research has shown that traditional environmental monitoring and enforcement are still dominant when the aim is to improve environmental quality in many countries (W. B. Gray & Shimshack, 2011). However, direct regulations are discussed controversially at the same time. For example, (R. Santos, Antunes, Ring, & Clemente, 2015) emphasize the limited ability to have an impact on broader land-use patterns and pressures undermining biodiversity and ecosystem services, while others doubt that regulations are flexible enough and able to appropriately deal with current environmental problems (Harring, 2014). As an example, enhancing landscape diversity is sometimes hindered by regulations that forbid or strongly limit converting woodland to agricultural land (Agnoletti, 2006). (Kenward et al., 2011) found that there is a lack of empirical evidence concerning the performance of particular governance strategies. Based on a novel analytical framework they analyzed 34 case studies and conclude that, while biodiversity conservation was positively associated with regulation, ecosystem service provisioning and regulation are negatively correlated. Their results seem to support a multiple-option approach, including both regulatory and market-based measures.

6.6.5.2 Economic and financial instruments

Beside taxation, economic and financial instruments currently play a minor role in mainstreaming biodiversity and nature's contributions to people (**Table 6.11**). However, there are further opportunities, such as price-based and quantity-based mechanisms, to incentivize environmentally friendly behaviour.

Price-based mechanisms

In the context of agricultural landscapes, Pascual & Perrings (2007) point out that changes in biodiversity are ultimately the result of decentralized decisions at the farm level, where land owners or users decide on the uptake of environmentally advantageous management practices. The correction of market failures is thus a necessary, but insufficient condition for effectively reducing biodiversity loss. Here, appropriate institutions can contribute to creating favourable conditions and incentives for farmers to act accordingly. However, for economic mechanisms to be effective, diverse environmental values have to be demonstrated, captured, and distributed to the individuals who actually bear the costs of conservation measures (TEEB, 2010). Furthermore, taking local traditional knowledge into account avoids a weakening of the traditionally strong relationship between human and natural systems (Babai & Molnár, 2014).

The effectiveness of price-based instruments is called into question given the often highly complex relationships between land-use practices and their actual impact on biodiversity and ecosystem services (Porrás et al., 2011). To develop this mechanism to an operational and efficient degree, the

following conditions should ideally be fulfilled: (i) assuring clear and enforceable property rights; (ii) increasing the number of buyers and sellers; (iii) providing complete information; (iv) reducing transaction costs and (v) avoiding entry and exit barriers to markets (Alvarado-Quesada, Hein, & Weikard, 2014). However, even if these conditions are met, it is still uncertain how to ensure conservation in the long run, given that governmental policies might change and insufficient future funding might reduce the credibility of market-based instruments and environmental governance as a whole. Further problems are related to leakage effects if negative effects are displaced instead of being reduced, and to lacking additionality in case that payments are made for practices that would have been adopted anyway (Porrás et al., 2011).

In general, there are two options for financing conservation; targeted and untargeted payments. Cudlínová, Lapka, & Bartos (1999) analyzed environmental subsidies in the Czech Republic and found they may be ineffective if the payments are not directed towards the appropriate target groups. By contrast, when appropriately targeted, subsidies can be very effective and essential for the continuity of traditional land-use systems (e.g. herding in the Pyrenees); up to an extent that herders substantially rely on such payments, which makes them particularly vulnerable to policy changes (Fernández-Giménez & Estaque, 2012). Mayrand & Paquin (2004) emphasize possible trade-offs between effectiveness, efficiency and equity (see **Figure 6.16**). While targeted payments might be effective, untargeted payments might be more equitable by including small scale land owners and more efficient by reducing transaction costs (Jack, Kousky, & Sims, 2008; Runhaar, 2016).

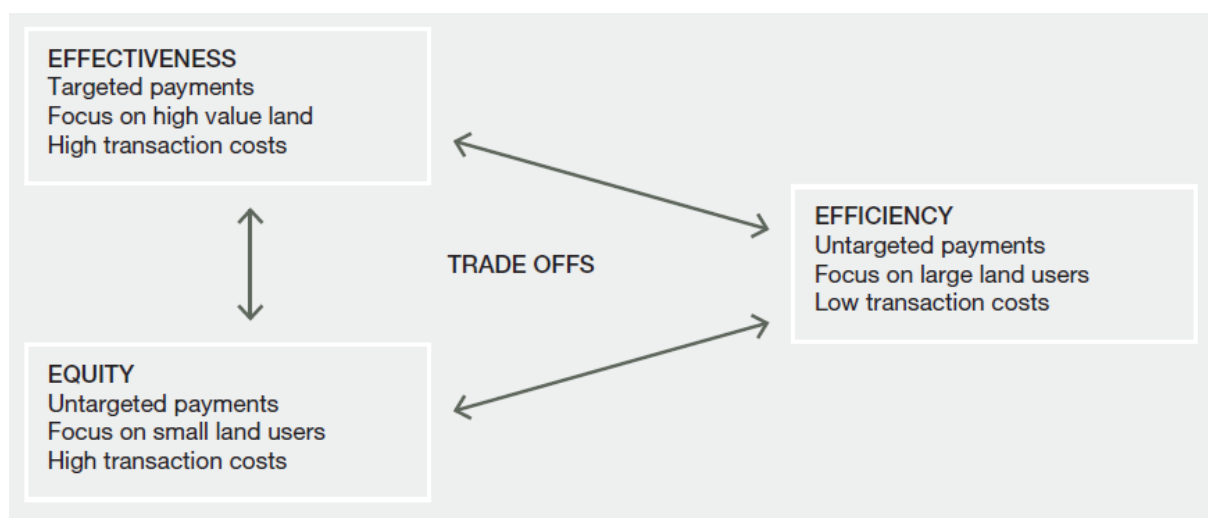


Figure 6.16: Trade-offs in implementing payment schemes. Source: adapted from (Mayrand & Paquin, 2004).

Quantity-based mechanisms

Tradable permits and habitat banking provide further opportunities for mainstreaming. They aim to offset environmental damages in one place by restoring habitats of equivalent ecological characteristics elsewhere (Wissel & Wätzold, 2010). The underlying principle of such biodiversity offsets is that of “no net loss” of biodiversity (Bull, Suttle, Gordon, Singh, & Milner-Gulland, 2013; Gardner et al., 2013). Due to their flexible character, such instruments are becoming increasingly popular. One of their advantages is seen in the ability to reduce information asymmetries: by using trading opportunities land owners reveal private information, that would otherwise not be available to public decision-makers, which can be used to enhance the effectiveness of the applied mechanism (Ring et al., 2010). Further, ensuring competitive conditions among potential service providers can lead to environmental solutions at lowest costs (Pirard, 2012). However, several practical drawbacks and

weaknesses have to be taken into account. Besides management and compliance problems, such concepts suffer from a flawed logical basis of the offset mechanism and *“immature, imprecise and complex science, which results in difficulties in determining biodiversity values”* (Burgin, 2008, p. 807). There are several dimensions in which destroyed and replaced habitat might differ: (i) the suitability of a site for certain species (dimension of type), (ii) the size and configuration of a site as well as distance and connectivity of sites (dimension of space), and (iii) the time it takes for a habitat to regenerate or for a species to recolonize (dimension of time) (Wissel & Wätzold, 2010). These differences might hinder the establishment of tradable permit markets, due to high transactions costs and difficulties in finding matching trading partners. Similar to the case of price-based instruments, there is a need for an appropriate institutional framework given that property rights are to be transferred. Furthermore, scientific expertise as well as local and indigenous knowledge are required. In contrast to carbon credits, where quantities are measured in a single and global metric (tonnes of CO₂ equivalents), other nature’s contributions to people comprise more complex aspects which can hinder trade at local and at coarser scales. This might be the reason why tradable right approaches in conservation are less successful in reality than corresponding mechanisms in markets for pollution and water rights (Reeson, 2015).

According to Santos and co-authors (R. Santos, Schröter-Schlaack, et al., 2015), it is hardly possible to draw a general conclusion on the effectiveness of quantity-based mechanisms. First, because the concept of “biodiversity markets” is still at an initial stage and there are only very few programs developing, mainly in Western Europe (European Union, France, Germany, Sweden, and UK) (Madsen, Carroll, Kandy, & Bennett, 2011; Madsen, Carroll, & Moore Brands, 2010). Second, available studies often refer to output-based indicators, such as area covered or credits traded, but it remains uncertain whether the goal of “no net loss” of biodiversity has actually been achieved. Under certain conditions, such as substantial ecological uncertainty or lack of legal safeguards for compliance (Bull et al., 2013), a precautionary approach by avoiding damages and protecting non-fungible habitats seems more appropriate.

6.6.5.3 Social and information-based instruments

The potential opportunities of social and information-based instruments are widely underutilized in Europe and Central Asia. While eco-labelling and environmental certification are quite frequently used approaches and private environmental reporting is increasing, the transparency and accountability of these voluntary instruments could be enhanced (Table 6.11).

Certification of resource production and trade

Producing and extracting resources in a more sustainable manner is an important strategy for sustainable production and consumption. To achieve this aim, social instruments such as voluntary market standards are increasingly being used (J. Potts et al., 2014). These standards contain a range of criteria for more efficient operational management and for production practices that positively affect environmental and socio-economic conditions. When production is verified for compliance to the standards’ criteria, the produced and traded resources are certified and labelled with well-known sustainability logos such as Forest Stewardship Council (FSC) for wood, Marine Stewardship Council (MSC) for caught fish and UTZ Certified for cacao. Further, the Fairtrade initiative addresses the imbalance of power in trading relationships and is based on a partnership of producers and consumers, including Central Asian countries, such as Kyrgyzstan and Uzbekistan (Fairtrade.net, 2012).

As a result of enhanced consumer awareness, business commitment and sustainable government procurement, the market shares of certified products have risen considerably on consumer good

34140 markets during the last decade (J. Potts et al., 2014). Concerning Europe and Central Asia, the only
 34141 sector with major certification activities is forestry. In 2013 the share of certified forested area (Forest
 34142 Stewardship Council and Programme for the Endorsement of Forest Certification) in the most forested
 34143 countries differed substantially, from less than 5% in the Russian Federation to about 80% in Poland
 34144 and more than 90% in Finland, Norway and Croatia (J. Potts et al., 2014). Special effort in further
 34145 countries and additional products is necessary, if voluntary standards are to operate effectively as tools
 34146 for environmental conservation and poverty reduction. Furthermore, sector-specific certification
 34147 standards, e.g. in forestry, do not consider the conservation of cultural landscapes as a whole.
 34148 Maintaining landscape mosaics by using traditional production patterns can increase the
 34149 competitiveness of goods, such as cheese or fruits, on national and international markets, while
 34150 contributing to local biodiversity and autonomy (Agnoletti, 2006; Demeulenaere & Bonneuil, 2010).

34151 In principle, market standards can be beneficial for conserving and enhancing ecosystem services
 34152 (Secretariat of the CBD & UNEP-WCMC, 2012). A desk-study on the monetary costs and benefits of
 34153 certified production that takes the value of ecosystem services explicitly into account showed that
 34154 certified production systems may offer effective and cost-efficient solutions for protecting and
 34155 safeguarding ecosystem services. However, a quick scan of a selection of standards reveals that not all
 34156 services are as yet equally well addressed and treated (van Oorschot et al., 2016). Furthermore, an
 34157 analysis of standard criteria suggests that newer, mainstream-oriented standards apply criteria of
 34158 reduced depth and breadth as a means to allow a more rapid market uptake (J. Potts et al., 2014).

34159 Although certification holds the promise of creating positive impacts in resource producing regions,
 34160 convincing proof on the positive impacts of certification on environmental and socio-economic
 34161 conditions is scarce and results are mixed (Blackman & Rivera, 2011; SCSKASC, 2012). A comprehensive
 34162 research agenda for standards has been developed (Milder et al., 2015; Milder, Gross, & Class, 2012),
 34163 spurred by cross-standard platforms for discussion and improving credibility, such as the International
 34164 Social and Environmental Accreditation and Labelling Alliance (ISEAL) (Loconto & Foulleux, 2014). Up
 34165 to now, the protection of nature's contributions to people has not been routinely and explicitly
 34166 addressed. Wider promotion of sustainable production standards, improving the ability of standards
 34167 to address ecosystem services, and conducting better impact research are all options to be pursued
 34168 for improving the outreach and effectiveness of this instrument. This might motivate private firms to
 34169 take proactive measures ahead of legislation, while later regulatory decisions will possibly be aligned
 34170 to the already developed practice (Lyon & Maxwell, 2002).

34171 Social and environmental reporting

34172 Social and environmental reporting is defined as all forms of non-financial reporting by business to
 34173 external stakeholders that focus on environmental, social and governance issues. Such reporting is
 34174 intended to measure consequences of economic activity not covered by traditional accounting systems
 34175 (R. Gray, 2010) and has grown and developed over the past decades (van der Esch & Steurer, 2014).
 34176 Although at present mainly focused on businesses, there is an emerging trend to extend it to other
 34177 institutions such as NGOs and government agencies at different levels (Owen, 2008). Non-financial
 34178 reporting is most often based on specific guidelines such as developed by the Global Reporting
 34179 Initiative (GRI), the Sustainability Accounting Standards Board (SASB) or the Natural Capital Coalition
 34180 (NCC, 2015). Those in turn may have a base in, or link to, more general, global principles.

34181 There are different internal and external drivers that may incentivize companies to engage in
 34182 sustainability reporting (see **Figure 6.17**). On top of that there are semi-mandatory rules, such as
 34183 intending as a company to comply with certain principles or guidelines that require reporting, and in
 34184 many countries legal obligations. In Europe and Central Asia, governments have created policies to

34185 stimulate or to mandate sustainability reporting by companies in their jurisdictions (van der Esch &
34186 Steurer, 2014).

INTERNAL ORIENTATION	Source: PBL pbl.nl	EXTERNAL ORIENTATION
Internal (i.e. employees) stakeholder communication		Anticipation of regulation
Product and process innovation		Competitive edge and public image
Internal management (efficiency, costs)		Attract investors
Risk management		External (i.e. community) stakeholder communication

34187
34188 **Figure 6.17: Company drivers for sustainability reporting and engagement of raters. Source: (van der**
34189 **Esch & Steurer, 2014).**

34190
34191 Characteristically, policies that stimulate non-financial reporting by companies are indirect. They use
34192 transparency as a tool that aims to set other changes in motion. This indirectness makes it complex to
34193 find evidence of the effectiveness and efficiency of environmental reporting policies, as additionality
34194 is hard to proof. At the user end, the data collected through non-financial reporting can be used for
34195 management, engagement and dialogue within the company, as well as by external stakeholders
34196 (**Figure 6.17**). Rating agencies use this information increasingly to guide and support investors, with
34197 large investors by now routinely incorporating this information in their decision-making framework.

34198
34199 *6.6.5.4 Rights-based instruments and customary norms*

34200 The current state of mainstreaming through rights-based instruments and customary norms has a huge
34201 potential for improvement. Despite the fact that rights-based approaches are at the very centre of the
34202 recently adopted Sustainable Development Goals, which aim at integrating human rights into all three
34203 dimensions of sustainable development (United Nations, 2015), our assessment shows that these
34204 types of instruments are rarely implemented and there are huge knowledge gaps in several sectors
34205 (**Table 6.11**). However, following the 2030-Agenda, we assume that the rights-based approach will be
34206 emphasized as an option to contribute to mainstreaming biodiversity and nature's contributions to
34207 people. To implement the Sustainable Development Goals agenda including the rights-based approach
34208 there is a need to develop more explicit guidelines for public and private decision-makers on how to
34209 contribute to e.g. the financing of development, an equitable trading system and a renewed and
34210 strengthened global partnership (Kindornay & Twigg, 2015).

34211 The rights-based approach also offers opportunities to identify problems and prospects related to, for
34212 example, the implementation of conservation policies in line with the Aichi Biodiversity Targets and
34213 the Sustainable Development Goals. The conservation of biodiversity has, on the one hand,
34214 contributed to the recognition of both procedural rights by safeguarding the right to participate in
34215 decision-making, and substantive rights by supporting sustainable natural resources and human
34216 wellbeing (Borrini-Feyerabend, Pimbert, Farvar, Kothari, & Renard, 2004). Conservation measures
34217 have, on the other hand, undermined or violated human rights, through human translocations,
34218 abolishment of traditional practices, centralization of governance and management or the
34219 prioritization of one industry (e.g., wildlife tourism) over traditional industries (e.g. live-stock herding)
34220 (Dowie, 2009).

34221 The application of the rights-based approach implies a need (i) to transform systemic and structural
34222 imbalances in power and (ii) to ensure participation in the governance and management of biodiversity
34223 and nature's contributions to people, thereby generating an opportunity to avoid such problems

related to conservation policies. However, there is also a need to further develop and implement policy instruments such as “free, prior, and informed consent” and the United Nations “protect, respect and remedy” framework (Campese et al., 2009; Hill & Lillywhite, 2015) for States to avoid violating the rights of indigenous people’s (W. M. Adams & Hutton, 2007; Anaya, 2015; Otis & Laurent, 2013; Reimerson, 2013) and to take diverse world views, trust issues, imbalance of power or hidden historical issues into consideration (Redpath, Gutiérrez, Wood, & Young, 2015). Through the promotion of a rights-based approach, instead of being the source of conflicts, indigenous peoples and local communities can often provide opportunities for learning about more sustainable natural resource uses. One positive example is the development of the joint knowledge generation by Hungarian herders and scientists (Z. Molnár et al., 2017).

6.6.5.5 Policy mix

Basically, a policy mix aims to overcome the flaws of single instruments with respect to effectiveness, efficiency and equity, while highlighting the functional role of the relevant instrument in the mix (Schröter-Schlaack & Ring, 2011). The different pathway narratives presented in Chapter 5 (Section 5.5.2) emphasize the opportunities of specific instrument mixes to achieve future developments. Several additional aspects call for an analysis and assessment of instruments within a broader policy mix: There are quite different ecosystems with different actors and multiple objectives involved. Furthermore, multiple drivers, sectors and governance levels have to be taken into account. In addition, existing policy regimes and sectoral policies already in place have decisive impact on the effectiveness and efficiency of new instruments to be implemented. Thus, there is a need for more systematic comparative analyses and empirical evidence to specify the interaction between new and traditional measures (Jordan et al., 2013).

Policy analysis considering the role of individual instruments in the real-world policy mix, including interactions with instruments within the same or from other policy sectors, has been mostly dealt with in climate and energy policies (Gawel, Strunz, & Lehmann, 2014; P. Lehmann, 2012; OECD, 2007; Sorrell & Sijm, 2003). Besides a few exceptions in the past (Barton et al., 2014; Gunningham & Young, 1997; Howlett & Rayner, 2006; Ring & Barton, 2015; Ring & Schröter-Schlaack, 2015; Schröter-Schlaack & Ring, 2011), policy mix analysis in biodiversity and ecosystem governance still holds some potential for further research and policy implementation, especially in a cross-sectoral perspective and spatially explicit analysis on the ground.

Direct regulations have often been the first choice for dealing with environmental problems, especially in the case of safeguarding against irreversible developments and overstepping ecological tipping points. In addition, they are seen as a precondition for the effectiveness of other instruments, for example by determining property rights before applying market-based instruments. However, given that direct regulation often neglects opportunity costs and equity aspects (including disregard of traditional and informal rights), their appropriateness can be questioned, and their acceptance can possibly be increased in combination with other instruments. In this regard, regulation and incentive-based instruments are seen as complements in a dual or multiple approach rather than substitutes (Kenward et al., 2011). Designing such policy mixes provides opportunities to mainstreaming biodiversity and nature’s contributions to people.

Taking the agricultural sector as an example (**Box 6.10**), the European Union’s cross-compliance mechanism combines direct payments with the compliance by farmers with basic regulatory standards concerning the environment, climate change, public health, food safety, animal and plant health and animal welfare, as well as the requirement of maintaining land in good agricultural and environmental

condition (European Union, 2013b). In addition, farmers may qualify for agri-environmental payments for agricultural practices, which go beyond cross-compliance and greening requirements (European Commission, 2013c). This policy design could be further adapted to mainstream and implement the concept of nature's contributions to people in sectors such as agriculture, forestry, fisheries and environmental policy and land-use planning. Legal and regulatory instruments in the form of environmental standards and requirements could be fine-tuned to approximate as much as possible the level of ecological thresholds or tipping points not to be trespassed. These standards can then be combined with economic and financial instruments to further promote the provision of selected contributions of nature to people by land users or fishermen.

Box 6.10: Mix of instruments in agri-environmental policy

Despite being criticized for setting too loose and general criteria for cross-compliance and greening (see also Section 6.5.1.3; Hauck et al., 2014; Hodge et al., 2015; Pe'er et al., 2014), the 2013 Common Agricultural Policy reform has made explicit the rationale underlying the policy design to achieve the delivery of public goods by both pillars of the policy (European Commission, 2013c). This policy architecture envisages the use and integration of different policy instruments (**Figure 6.18a**). This strategy is implemented by requiring farmers to respect cross-compliance requirements (some of which are based on European Union environmental legislation such as the Water Framework Directive and Nitrate Directive) to be eligible for 70% of direct payments, and of greening requirements to be eligible for the remaining 30% of direct payments under pillar 1. Once farmers have respected both cross-compliance and greening requirements they are eligible to enroll in voluntary agri-environmental measures with payments under pillar 2 for agricultural practices which go beyond cross-compliance and greening requirements (European Commission, 2013c). Furthermore, administrative penalties may be applied as in cases of non-compliance with eligibility criteria, commitments or other obligations resulting from the application of agricultural legislation (European Union, 2013b) (**Figure 6.18a**).

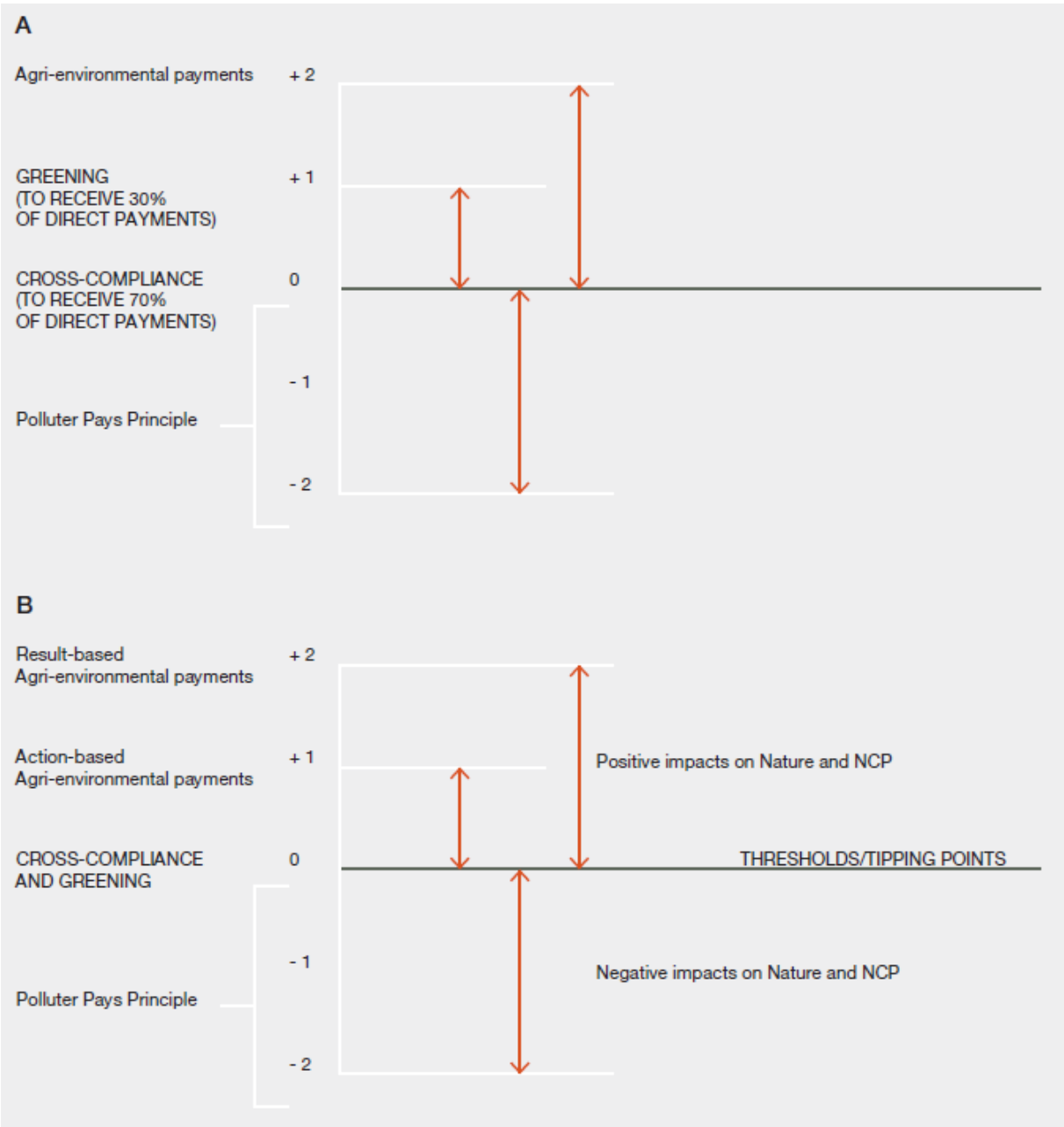


Figure 6.18: a) Integration of different agri-environmental policy instruments by the 2013 reform of the European Union's Common Agricultural Policy; b) Example of integrating further policy instruments with additional benefits for biodiversity conservation and the sustained delivery of nature's contributions to people in the policy mix. Source: Own representation.

This policy architecture could be adapted to mainstream and to implement the concept of nature's contributions to people (Figure 6.18b). This can be done by fine tuning cross-compliance and greening requirements to approximate as much as possible the level of ecological thresholds or tipping points not to be trespassed in a specific agro-ecosystem to achieve the delivery of selected contributions of nature to people. Above this reference level payments for agri-environment-climate measures could be tailored to specific nature's contributions to people or local conditions by allowing farmers to choose between action- or result-based agri-environmental payments (Section 6.5.1.3) to enhance the nature's contributions to people delivery beyond thresholds or tipping points (Figure 6.18b). The effectiveness and efficiency of result-oriented agri-environmental measures could be further enhanced by issuing territorial contracts for groups of farmers to reach the critical mass necessary to deliver selected nature's contributions to people and at the same time reducing transaction costs.

34309 **End of Box 6.10**

34310 Policy mix analysis is also essential from a cross-sectoral perspective where policies in one sector (e.g.,
 34311 climate, fisheries, energy or agriculture) may jeopardize policies in other sectors (e.g., nature
 34312 conservation). A comprehensive policy mix also comprises the integration of environmental aspects in
 34313 non-environmental policy sectors, with the aims (i) to reduce conflicts between sectoral policies and
 34314 (ii) to directly target the drivers of environmental pressures and degradation (Runhaar, Driessen, &
 34315 Uittenbroek, 2014). For example, publicly financed support programmes for biodiversity measures on
 34316 farmland can hardly be effective if, at the same time and in the same area, public subsidies favour
 34317 agricultural intensification and monocultures to increase bioenergy production (Natural Capital
 34318 Germany - TEEB-DE, 2015). However, scientific insight is scarce concerning the reasons for hindering
 34319 or favouring policy integration (Biesbroek, Klostermann, Termeer, & Kabat, 2013; Brouwer, Rayner, &
 34320 Huitema, 2013). This calls for the development of a systematic framework for the analysis of effective
 34321 policy integration strategies (Runhaar et al., 2014).

34322 For environmental policy instruments to be effective, they have to be supported by the general public
 34323 (Harring, 2014). Here, attitudes and judgements concerning specific instruments vary substantially
 34324 across countries. Combining scientific evidence with legal, political and social institutions can be a
 34325 promising approach for balancing environmental protection and development. Further, economic
 34326 instruments should not only focus on private actors but also include the role of public actors and
 34327 promote a *“mindset of cooperation and shared responsibility”* (R. Santos, Antunes, et al., 2015, p. 94).
 34328 Such a mindset could also contribute to overcoming aspects of procedural and distributive justice and
 34329 comprise an equitable integration of scientific insights and lay knowledge (Paloniemi et al., 2015). The
 34330 dialogue and engagement of different actors in the political process is not a novel phenomenon
 34331 (EUFORGEN, 2017). The important issues are how actors cooperate and which combination of actors
 34332 is most effective in providing successful governance (Peters, 2014). The policy outcomes concerning
 34333 non-governmental certification in the forestry and fishery sector are examples of public-private policy
 34334 interaction at multiple levels. However, more research is needed to identify causal mechanisms and to
 34335 explore whether sector-specific solutions are successfully applicable within and across other sectors
 34336 (Gulbrandsen, 2014). Concerning Central Asia, a recently finished European Union FP7-research
 34337 project assessed the policy mix in the field of science and innovation (IncoNet Central Asia, 2016). The
 34338 applied peer-review exercise could serve as an example for a similar initiative related to nature’s
 34339 contributions to people.

34340 **Box 6.11** presents a policy-mix analysis for the Norwegian system of fisheries management based on
 34341 the IPBES categories of policy instruments and families of policy support tools and methodologies
 34342 (IPBES, 2016b; Lasson, 2016). Norway’s experience has shown that it is possible to drastically reduce
 34343 subsidies without destroying the industry (M. Lehmann et al., 2011; OECD, 2006a) and it provides a
 34344 best-practice example of how considering relevant actors and various policy instruments in a mix can
 34345 lead to effective outcomes. Therefore, integrating and mainstreaming biodiversity into key sectors and
 34346 policies is a major strategic goal, at national, regional and global levels (CBD, 2010; European
 34347 Commission, 2011a).

34348 **Box 6.11: Policy mix analysis of the Norwegian system of fisheries management**

34349 Today’s system of fisheries management in Norway is often cited as best practice of effective and well-
 34350 coordinated policymaking, which is, however, the result of decades of gradual reforms. As a major paradigm
 34351 shift, sustainable resource management instead of state support to industry became the main management
 34352 priority. The ecosystem approach is now a central principle in fisheries management, which at the same time is
 34353 increasingly coordinated with other marine uses. Since the 1990s, the negative trend in stock levels has been
 34354 reversed: major stocks have been rebuilt or are still in the rebuilding phase, and catches and profitability of the
 34355 sector increased (Gullestad et al., 2014; Misund, 2014).

34356 Within the policy mix, legal and regulatory instruments naturally play a key role. Limiting access to fisheries and
 34357 reducing the number of vessels was the starting point of reforms in the 1970s (Misund, 2014; OECD, 2013a, p.
 34358 369). Also, overall quotas were cut and are mostly set according to scientific advice (Diamond & Beukers-Stewart,
 34359 2011). Limiting access to fisheries by licenses is a form of rights-based instruments and customary norms: today,
 34360 all offshore and most coastal fisheries are access-regulated. To mitigate social impacts, a number of free access
 34361 licenses are granted to young fishermen in small-scale coastal fisheries (Eliassen, Sverdrup-Jensen, Holm, &
 34362 Johnsen, 2009, p. 31). In 2011, an agreement was reached with the indigenous Sami population regarding their
 34363 fishing rights and increased involvement in decision-making (Norwegian Ministry of Foreign Affairs, 2012, p. 114;
 34364 OECD, 2013a, p. 369).

34365 One of the main economic and financial instruments in fisheries management are subsidies. In the mid-1960s,
 34366 Norwegian fisheries started to be heavily subsidized, which counteracted both conservation and profitability
 34367 objectives. It took until the early 1980s when the problem was addressed and subsidies started to be reduced.
 34368 Since then, they have been temporarily increased to buffer short-term crisis in the sector but have been cut to a
 34369 negligible level since the mid-1990s. Another economic instrument concerns the discard ban: to increase
 34370 compliance of fishermen – which is arguably hard to enforce on the high seas – they can keep, under certain
 34371 conditions, a percentage of the sales value of their landed bycatch.

34372 Transparency is considered an important element of social and information-based instruments. A database
 34373 containing the fishing licenses and quotas for each vessel is publicly available; an instrument that is assumed to
 34374 enhance compliance with regulations. The same effect is attributed to the fact that the fishing industry is given
 34375 responsibility in terms of monitoring and self-control. Environmental education and awareness campaigns are
 34376 carried out by agencies which are also involved in fisheries management, for example in the development of the
 34377 integrated ocean management plans.

34378 The overall effectiveness of the policy mix is closely tied to a range of policy support tools and methodologies.
 34379 Namely a trustful and well-established cooperation with the fishing industry and increasingly also other
 34380 stakeholders, and extensive monitoring of both ecosystems and fisheries in combination with strict enforcement
 34381 contribute to the viability of policy instruments. **Table 6.12** shows an exemplary overview of these and other
 34382 support tools.

34383 **Table 6.12: Examples of policy support tools and methodologies in Norwegian fisheries**
 34384 **management.**

Assembling data and knowledge	Scientific surveys increasingly run as “ecosystem cruises”, collecting data not only on fish but also on plankton, benthos, marine mammals and seabirds as well as on oceanographic conditions. Additional data are collected by the Norwegian Reference Fleet, a group of commercial fishing vessels performing scientific sampling of their catch.
Assessment and evaluation	Biophysical ecosystem considerations in stock assessments, for example modeling predator-prey relationships
Public discussion, involvement and participatory process	Formal and informal involvement of fishermen’s associations and other stakeholders in quota setting, allocation and other management issues, with positive effects on legitimacy and compliance.
Selection and design of policy instruments	Fisheries legislation mainly as enabling acts, delegating decision-making power to administration and de-coupling it from shifting political agendas; strong commitment to conservation goals. “Stock and Fisheries tables” as tool to prioritize policy requirements and as basis for discussion with stakeholders.
Implementation, outreach and enforcement	High coverage of Coast Guard inspections, carried out in respectful and non-provocative manner
Training and capacity building	Training of scientists and Coast Guard inspectors in international collaboration, especially with Russia.
Social learning, innovation and adaptive governance	Regular formal and informal meetings between stakeholders and managers at national and local scales (Gullestad, Abotnes, & Bakke, 2017; Mikalsen & Jentoft, 2003). General openness of system to innovation and testing of new policies (Gullestad, Blom, Bakke, & Bogstad, 2015).

End of Box 6.11

6.6.6 Safeguarding biodiversity, nature's contributions to people and good quality of life in a changing world

The design of promising governance options and smart institutional arrangements is central to the conservation and sustainable use of biodiversity and nature's contributions to people. Mainstreaming biodiversity and nature's contributions to people into different sectors at multiple scales is a crucial precondition to achieving long-term human wellbeing and sustainable development (CBD, 2016a; Meadowcroft et al., 2012; UNEP & UNECE, 2016; United Nations, 2015). How we choose to organize our societies – both the public and the private spheres - is key for the realization of pathways towards a world with ecosystems capable of meeting future human needs (see Chapter 5). Hence, the literature on governance towards sustainability focuses in particular on finding promising governance modes (or mixes of modes) suitable to promote sustainable development (Lange et al., 2013). Our assessment shows that new modes of governance, such as decentralization, public-private partnerships or private forms of governance, increasingly emerge in parallel to traditional hierarchical governance. They allow better involvement of different actors in policy and decision-making with the aim of promoting shared responsibility for our common future. However, due to the intrinsic complexity of human societies, there is no single panacea for successful governance of biodiversity and nature's contributions to people (Ostrom, Janssen, & Anderies, 2007).

To govern complexity or complex adaptive systems (see Chapter 4), which often includes various forms of incomplete knowledge, and involves risk, uncertainty, ambiguity or even ignorance (Leach, Scoones, & Stirling, 2010), it is frequently argued that the design of promising governance options should aim at building robustness, enhancing resilience, and considering risk. While robustness refers to the maintenance of system performance to avoid disruption (Anderies & Janssen, 2013), resilience measures the maximum disturbance of a system before flipping to a different state (Walker, Holling, Carpenter, & Kinzig, 2004), and can be characterized as *“a kind of insurance against reaching a non-desired state.”* (Mäler & Li, 2010, p. 708). A risk approach has a slightly different focus of enabling societies to benefit from change while minimizing the negative consequences of associated risks (Lidskog, Soneryd, & Ugglå, 2010). While the concepts are appealing, resilience in particular can be difficult to apply to designed or managed systems (Rist & Moen, 2013), while robustness and risk, which explicitly build on designed systems, often fail to make necessary trade-offs (Barnett & Anderies, 2014). Nevertheless, the various approaches to governance of complexity share important characteristics, since they all promote policy processes that stimulate adaptation and learning. Hence, to take up the challenge of successfully governing complexity and better adapting policies and instruments to specific contexts, approaches of biodiversity conservation and mainstreaming into sectoral policies, programmes and strategies need to be seen as experiments that require (i) governance and management for change, rather than against change, and (ii) systematic continuous monitoring and evaluation (Rist & Moen, 2013). This can be achieved incrementally through adaptive governance and management and the systematic improvement of policy implementation (Hasselman, 2017), or via transition governance and management, and the organization of evolutionary processes of societal change (Mårald, Sandström, & Nordin, 2017).

Over the last three decades promising governance modes have emerged that support biodiversity conservation and mainstreaming in Europe and Central Asia. However, our assessment shows that there are underutilized opportunities for policy integration and mainstreaming that might facilitate

34430 the transition towards an inclusive green economy (see e.g. “Greening Economies in the Eastern
34431 Neighbourhood Programme” (EaP-Green) (UNEP & UNECE, 2016, p. 154). Developing and improving
34432 governance systems to promote adaptive or transition management is therefore essential, if public
34433 and private actors are to achieve the overarching objective of safeguarding biodiversity, nature’s
34434 contributions to people and good quality of life. Mainstreaming biodiversity and nature’s contributions
34435 to people along the three key steps of raising awareness, defining policy objectives, and designing
34436 policies and instruments (**Figure 6.13**) is crucial to the success of this endeavour.

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- 37288

Glossary

- 37289
37290
- 37291 **Abundance (ecological)** The size of a population of a particular life form in a given area.
- 37292 **Acceptance** Acceptance of the Platform's outputs at a session of the Plenary signifies that the
37293 material has not been subjected to line-by-line discussion and agreement, but nevertheless presents
37294 a comprehensive and balanced view of the subject matter.
- 37295 **Acidification** Ongoing decrease in pH away from neutral value of 7. Often used in reference to
37296 oceans, freshwater or soils, in response to uptake of carbon dioxide from the atmosphere.
- 37297 **Actor** Individual person or group representative that is involved in a specific decision-making context
- 37298 **Adaptation** Adjustment in natural or human systems to a new or changing environment, whether
37299 through genetic or behavioural change.
- 37300 **Adaptive capacity** The general ability of institutions, systems, and individuals to adjust to potential
37301 damage, to take advantage of opportunities, or to cope with the consequences.
- 37302 **Adaptive management** A systematic process for continually improving management policies and
37303 practices by learning from the outcomes of previously employed policies and practices. In active
37304 adaptive management, management is treated as a deliberate experiment for purposes of learning.
- 37305 **Afforestation** Converting grasslands or shrublands into tree plantations. Afforestation is sometimes
37306 suggested as a tool to sequester carbon, but it can have negative impacts on biodiversity and
37307 ecosystem function, for example by reducing runoff, and so decreasing water production.
- 37308 **Agenda setting** One of four phases in the policy cycle. Agenda setting motivates and sets the
37309 direction for policy design and implementation. Usually, adoption is carried out for a Summary for
37310 Policymakers, rather than for a full assessment (which would be subject to acceptance).
- 37311 **Agri-environmental schemes** Schemes that provide funding to farmers and land managers to farm
37312 in ways that supports biodiversity, enhance the landscape, and improve the quality of water, air and
37313 soil (see also agroecology as integral to such schemes).
- 37314 **Agricultural intensification** An increase in agricultural production per unit of inputs (which may be
37315 labour, land, time, fertilizer, seed, feed or cash).
- 37316 **Agrobiodiversity** Agricultural biodiversity is a broad term that includes all components of biological
37317 diversity of relevance to food and agriculture, and all components of biological diversity that
37318 constitute the agricultural ecosystems, also named agro-ecosystems: the variety and variability of
37319 animals, plants and micro-organisms, at the genetic, species and ecosystem levels, which are
37320 necessary to sustain key functions of the agro-ecosystem, its structure and processes (CBD COP
37321 decision V/5, appendix). Agricultural biodiversity is the outcome of the interactions among genetic
37322 resources, the environment and the management systems and practices used by farmers, in some
37323 cases over millennia.
- 37324 **Agroecology** The science and practice of applying ecological concepts, principles and knowledge
37325 (i.e., the interactions of, and explanations for, the diversity, abundance and activities of organisms)
37326 to the study, design and management of sustainable agroecosystems. It includes the roles of human
37327 beings as a central organism in agroecology by way of social and economic processes in farming
37328 systems. Agroecology examines the roles and interactions among all relevant biophysical, technical
37329 and socioeconomic components of farming systems and their surrounding landscapes.

- 37330 **Agroecosystem** An ecosystem, dominated by agriculture, which provides specific contributions to
 37331 people, and possesses assets and functions such as biodiversity, ecological succession and food webs.
- 37332 **Agroforestry** A collective name for land-use systems and technologies where woody perennials
 37333 (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land-management units as
 37334 agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence.
 37335 Agroforestry can enhance the food supply, income and health of smallholder farmers and other rural
 37336 people.
- 37337 **Aichi Biodiversity Targets** The 20 targets set by the Conference of the Parties to the Convention for
 37338 Biological Diversity (CBD) at its tenth meeting, under the Strategic Plan for Biodiversity 2011-2020.
- 37339 **Alien species** See "invasive alien species".
- 37340 **Animism** The attribution of a living soul to plants, inanimate objects, and natural phenomena.
- 37341 **Annual** In Botany, refers to plants that grow from seed to maturity, reproduction and death in one
 37342 year. Related terms are biennial (plants that take two years to complete their life cycles), and
 37343 perennial (plants that take several many years to complete their life cycles).
- 37344 **Anthropocentric value** See "values".
- 37345 **Anthropogenic assets** Built-up infrastructure, health facilities, or knowledge - including indigenous
 37346 and local knowledge systems and technical or scientific knowledge - as well as formal and non-formal
 37347 education, work, technology (both physical objects and procedures), and financial assets.
 37348 Anthropogenic assets have been highlighted to emphasize that a good quality of life is achieved by a
 37349 co-production of benefits between nature and people.
- 37350 **Approval** Approval of the Platform's outputs signifies that the material has been subject to detailed,
 37351 line-by-line discussion and agreement by consensus at a session of the Plenary.
- 37352 **Aquaculture** The farming of aquatic organisms, including fish, molluscs, crustaceans and aquatic
 37353 plants, involving interventions such as regular stocking, feeding, protection from predators, to
 37354 enhance production. (In contrast, aquatic organisms which are exploitable by the public as a common
 37355 property resource, are classed as fisheries, not aquaculture).
- 37356 **Archetypes** In the context of scenarios, an over-arching scenario that embodies common
 37357 characteristics of a number of more specific scenarios.
- 37358 **Aridification** A chronic reduction in soil moisture caused by an increase of mean annual temperature
 37359 or a decrease in yearly precipitation.
- 37360 **Assessment reports** Assessment reports are published outputs of scientific, technical and
 37361 socioeconomic issues that take into account different approaches, visions and knowledge systems,
 37362 including global assessments of biodiversity and ecosystem services with a defined geographical
 37363 scope, and thematic or methodological assessments based on the standard or the fast-track
 37364 approach. They are to be composed of two or more sections including a summary for policymakers,
 37365 an optional technical summary and individual chapters and their executive summaries. Assessments
 37366 are the major output of IPBES, and they contain syntheses of findings on topics that have been
 37367 selected by the IPBES Plenary.
- 37368 **Baseline** A minimum or starting point with which to compare other information (e.g. for comparisons
 37369 between past and present or before and after an intervention).
- 37370 **Beneficiary** Different social actors and groups who may be benefiting from nature and ES in different
 37371 ways and to different degrees, including individual, household or collective levels

- 37372 **Benefit sharing** Distribution of benefits between stakeholders.
- 37373 **Benefits** Advantage that contributes to wellbeing from the fulfilment of needs and wants. In the
37374 context of nature's contributions to people.
- 37375 **Benthic** Occurring at the bottom of a body of water; related to benthos.
- 37376 **Benthos** A group of organisms, other invertebrates, that live in or on the bottom in aquatic habitats.
- 37377 **Biocentric perspectives** Recognising the importance of non-human life.
- 37378 **Biocultural diversity** The diversity exhibited collectively by natural and cultural systems. It
37379 incorporates three concepts: firstly, that the diversity of life includes human cultures and languages;
37380 secondly, that links exist between biodiversity and human cultural diversity; and finally, that these
37381 links have developed over time through mutual adaptation and possibly co-evolution between
37382 humans, plants and animals.
- 37383 **Biodiversity** The variability among living organisms from all sources including terrestrial, marine and
37384 other aquatic ecosystems and the ecological complexes of which they are a part. This includes
37385 variation in genetic, phenotypic, phylogenetic, and functional attributes, as well as changes in
37386 abundance and distribution over time and space within and among species, biological communities
37387 and ecosystems.
- 37388 **Biodiversity hotspot** A generic term for an area high in such biodiversity attributes as species
37389 richness or endemism. It may also be used in assessments as a precise term applied to geographic
37390 areas defined according to two criteria: (i) containing at least 1,500 species of the world's 300,000
37391 vascular plant species as endemics, and (ii) being under threat, in having lost 70 % of its primary
37392 vegetation.
- 37393 **Biodiversity loss** The reduction of any aspect of biological diversity (i.e. diversity at the genetic,
37394 species and ecosystem levels) is lost in a particular area through death (including extinction),
37395 destruction or manual removal; it can refer to many scales, from global extinctions to population
37396 extinctions, resulting in decreased total diversity at the same scale.
- 37397 **Biodiversity offset** A biodiversity offset is a tool proposed by developers and planners for
37398 compensating for the loss of biodiversity in one place by biodiversity gains in another.
- 37399 **Biofuel** Fuel made from biomass.
- 37400 **Biological diversity** See "biodiversity"
- 37401 **Biomass** The mass of non-fossilized and biodegradable organic material originating from plants,
37402 animals and micro-organisms in a given area or volume.
- 37403 **Biome** Biomes are global-scale zones, generally defined by the type of plant life that they support in
37404 response to average rainfall and temperature patterns. For example, tundra, coral reefs or savannas.
- 37405 **Biosphere** The sum of all the ecosystems of the world. It is both the collection of organisms living on
37406 the Earth and the space that they occupy on part of the Earth's crust (the lithosphere), in the oceans
37407 (the hydrosphere) and in the atmosphere. The biosphere is all the planet's ecosystems.
- 37408 **Biota** All living organisms of an area; the flora and fauna considered as a unit.
- 37409 **Biotic homogenization** See "homogenisation"
- 37410 **Bureau** The IPBES Bureau is a subsidiary body established by the Plenary which carries out the
37411 governance functions of the Platform. It is made up of representatives nominated from each of the
37412 United Nations regions, and is chaired by the Chair of IPBES.

- 37413 **Bushmeat** Meat for human consumption derived from wild animals.
- 37414 **Bycatch** The commercially undesirable species caught during a fishing process.
- 37415 **Cap-and-trade** An economic policy instrument in which the State sets an overall environmental
37416 target (the cap) and assigns environmental impact allowances (or quotas) to actors that they can
37417 trade among each other.
- 37418 **Capacity-building (or development)** Defined by the United Nations Development Programme as
37419 “the process through which individuals, organisations and societies obtain, strengthen and maintain
37420 their capabilities to set and achieve their own development objectives over time”. IPBES promotes
37421 and facilitates capacity-building, to improve the capacity of countries to make informed policy
37422 decisions on biodiversity and ecosystem services.
- 37423 **Carbon cycle** The carbon cycle is the process by which carbon is exchanged among the ecosystems
37424 of the Earth.
- 37425 **Carbon sequestration** The long-term storage of carbon in plants, soils, geologic formations, and the
37426 ocean. Carbon sequestration occurs both naturally and as a result of anthropogenic activities and
37427 typically refers to the storage of carbon that has the immediate potential to become carbon dioxide
37428 gas.
- 37429 **Carbon storage** The technological process of capturing waste carbon dioxide from industry or power
37430 generation, and storing it so that it will not enter the atmosphere.
- 37431 **Carrying capacity** The upper limit of habitats, ecosystems, landscapes, waterscapes or seascapes or
37432 any other appropriate geographic unit to provide tangible and intangible goods and services
37433 (including aesthetics and spiritual services) in a sustained way without altering its bio-geo-chemical
37434 characteristics, ecosystem functions and endangering its own resilience to climate change, natural
37435 and anthropogenic perturbations.
- 37436 **Catalogue of policy support tools and methodologies** The IPBES catalogue of policy support tools
37437 and methodologies is an evolving online resource with two main goals. The first goal is to enable
37438 decision makers to gain easy access to information on policy support tools and methodologies to
37439 better inform and assist the different phases of policy-making and implementation. The second goal
37440 is to allow a range of users to provide input to the catalogue and assess the usability of tools and
37441 methodologies in their specific contexts, including resources required and types of outputs that can
37442 be obtained, thus helping to identify and bridge gaps with respect to available tools and
37443 methodologies.
- 37444 **Certainty** In the context of IPBES, the summary terms to describe the state of knowledge are the
37445 following:
- 37446 • Well established (Certainty term (q.v.)): comprehensive meta-analysis or other synthesis or
37447 multiple independent studies that agree.
 - 37448 • Established but incomplete (Certainty term (q.v.)): general agreement although only a limited
37449 number of studies exist but no comprehensive synthesis and, or the studies that exist
37450 imprecisely address the question.
 - 37451 • Unresolved (Certainty term (q.v.)): multiple independent studies exist but conclusions do not
37452 agree.
 - 37453 • Inconclusive (Certainty term (q.v.)): limited evidence, recognising major knowledge gaps.
- 37454 **Citizens/laypeople** Actors living in the area / context of interest that are directly or indirectly
37455 impacted by decisions / recommendations and hold their own (subjective) interest

- 37456 **Climate change** As defined in Article 1 of the UNFCCC, "a change of climate which is attributed
37457 directly or indirectly to human activity that alters the composition of the global atmosphere and
37458 which is in addition to natural climate variability observed over comparable time periods "
- 37459 **Co-management** Process of management in which government shares power with resource users,
37460 with each given specific rights and responsibilities relating to information and decision-making.
- 37461 **Co-production** In the context of the IPBES conceptual framework, this is the joint contribution by
37462 nature and anthropogenic assets in generating nature's contributions to people.
- 37463 **Community based monitoring and information systems (CBMIS)** It refers to initiatives by indigenous
37464 peoples and local community organizations to monitor their community's well-being and the state of
37465 their territories and natural resources, applying a mix of traditional knowledge and innovative tools
37466 and approaches. It is a system that promotes evidence-based policy making while empowering
37467 communities to participate in the process
- 37468 **Community-based natural resource management** Community-based natural resource
37469 management: an approach to natural resource management that involves the full participation of
37470 indigenous peoples' and local communities and resource users in decision-making activities, and the
37471 incorporation of local institutions, customary practices, and knowledge systems in management,
37472 regulatory, and enforcement processes. Under this approach, community-based monitoring and
37473 information systems are initiatives by indigenous peoples and local community organisations to
37474 monitor their community's well-being and the state of their territories and natural resources,
37475 applying a mix of traditional knowledge and innovative tools and approaches.
- 37476 **Conservation agriculture** Approach to managing agro-ecosystems for improved and sustained
37477 productivity, increased profits and food security while preserving and enhancing the resource base
37478 and the environment. It is characterized by three linked principles, namely: 1) continuous minimum
37479 mechanical soil disturbance; 2) permanent organic soil cover; and 3) diversification of crop species
37480 grown in sequences and/or associations. This covers a wide range of approaches from minimum till
37481 to permaculture/"mimicking nature".
- 37482 **Corridor** A geographically defined area which allows species to move between landscapes,
37483 ecosystems and habitats, natural or modified, and ensures the maintenance of biodiversity and
37484 ecological and evolutionary processes.
- 37485 **Cost-benefit analysis** A technique designed to determine the feasibility of a project or plan by
37486 quantifying its costs and benefits
- 37487 **Cropland** A land cover/use category that includes areas used for the production of crops for harvest.
- 37488 **Cross-scale analysis** Cross-scale effects are the result of spatial and/or temporal processes
37489 interacting with other processes at another scale. These interactions create emergent effects that
37490 can be difficult to predict.
- 37491 **Cross-sectoral** Relating to interactions between sectors (that is, the distinct parts of society, or of a
37492 nation's economy), such as how one sector affects another sector, or how a factor affects two or
37493 more sectors.
- 37494 **Customary law** Customary law is law based on tradition in communities where the authority of
37495 traditional leadership is recognised. It exists where there is a commonly repeated practice which is
37496 accepted as law by the members of a community.
- 37497 **Decomposition** Breakdown of complex organic substances into simpler molecules or ions by
37498 physical, chemical and/or biological processes

- 37499 **Deforestation** Human-induced conversion of forested land to non-forested land. Deforestation can
 37500 be permanent, when this change is definitive, or temporary when this change is part of a cycle that
 37501 includes natural or assisted regeneration.
- 37502 **Degraded land** Land in a state that results from persistent decline or loss of biodiversity and
 37503 ecosystem functions and services that cannot fully recover unaided.
- 37504 **Denitrification** A heterotrophic process of anaerobic microbial respiration conducted by bacteria.
 37505 Denitrification is the microbial oxidation of organic matter in which nitrate or nitrite is the terminal
 37506 electron acceptor, and the end product is N₂.
- 37507 **Desertification** Land degradation in arid, semi-arid and dry sub-humid areas resulting from various
 37508 factors, including climatic variations and human activities. Desertification does not refer to the
 37509 natural expansion of existing deserts.
- 37510 **Direct driver** See "driver".
- 37511 **Disservices** Undesired negative effects from not very well adapted land use and management that
 37512 addresses the provision of different E
- 37513 **Distributional equity/justice** Allocation of costs, benefits, risks and responsibilities as well as of the
 37514 products of nature requiring the disaggregation of values to highlight who benefits and who loses,
 37515 and to demonstrate the consequences for those affected
- 37516 **Double counting of services** Erroneously including the same ecosystem service more than once in
 37517 an economic analysis
- 37518 **Downscaling** The transformation of information from coarser to finer spatial scales through
 37519 statistical modelling or spatially nested linkage of structural models.
- 37520 **Driver** In the context of IPBES, drivers of change are all the factors that, directly or indirectly, cause
 37521 changes in nature, anthropogenic assets, nature's contributions to people and a good quality of life.
 37522 Direct drivers of change can be both natural and anthropogenic. Direct drivers have direct physical
 37523 (mechanical, chemical, noise, light etc.) and psychological (disturbance etc.) impacts on nature and
 37524 its functioning, and on people and their interaction. Direct drivers unequivocally influence
 37525 biodiversity and ecosystem processes. Direct drivers include, inter alia, climate change, pollution,
 37526 land use change, invasive alien species and zoonoses, including their effects across regions. Indirect
 37527 drivers are drivers that operate diffusely by altering and influencing direct drivers as well as other
 37528 indirect drivers (also referred to as 'underlying causes'). Interactions between indirect and direct
 37529 drivers create different chains of relationship, attribution, and impacts, which may vary according to
 37530 type, intensity, duration, and distance. These relationships can also lead to different types of spill-
 37531 over effects. Global indirect drivers include economic, demographic, governance, technological and
 37532 cultural ones, among others. Special attention is given, among indirect drivers, to the role of
 37533 institutions (both formal and informal) and impacts of the patterns of production, supply and
 37534 consumption on nature, nature's contributions to people and good quality of life.
- 37535 **Drylands** Arid, semi-arid and dry sub-humid areas. The term excludes hyper-arid areas, also known
 37536 as deserts. Drylands are characterised by water scarcity and cover approximately 40 % of the world's
 37537 terrestrial surface.
- 37538 **Eco-region** A large area of land or water that contains a geographically distinct assemblage of natural
 37539 communities that: (a) Share a large majority of their species and ecological dynamics; (b) Share similar
 37540 environmental conditions, and; (c) Interact ecologically in ways that are critical for their long-term
 37541 persistence (source: WWF). In contrast to biomes, an ecoregion is generally geographically specific,

37542 at a much finer scale. For example, the “East African Montane Forest” eco-region of Kenya (WWF
 37543 eco-region classification) is a geographically specific and coherent example of the globally occurring
 37544 “tropical and subtropical forest” biome.

37545 **Ecological community** An assemblage or association of populations of two or more different species
 37546 occupying the same geographical area and in a particular time.

37547 **Ecological footprint** A measure of the amount of biologically productive land and water required to
 37548 support the demands of a population or productive activity. Ecological footprints can be calculated
 37549 at any scale: for an activity, a person, a community, a city, a region, a nation or humanity as a whole.

37550 **Ecological infrastructure** Ecological infrastructure refers to the natural or semi-natural structural
 37551 elements of ecosystems and landscapes that are important in delivering ecosystem services. It is
 37552 similar to 'green infrastructure', a term sometimes applied in a more urban context. The ecological
 37553 infrastructure needed to support pollinators and improve pollination services includes patches of
 37554 semi-natural habitats, including hedgerows, grassland and forest, distributed throughout productive
 37555 agricultural landscapes, providing nesting and floral resources. Larger areas of natural habitat are also
 37556 ecological infrastructure, although these do not directly support agricultural pollination in areas more
 37557 than a few kilometers away from pollinator-dependent crops.

37558 **Economic and financial instruments** Economic and financial instruments can be used to change
 37559 people’s behavior towards desired policy objectives. Instruments typically encompass a wide range
 37560 of designs and implementation approaches. They include traditional fiscal instruments, including for
 37561 example subsidies, taxes, charges and fiscal transfers. Additionally, instruments such as tradable
 37562 pollution permits or tradable land development rights rely on the creation of new markets. Further
 37563 instruments represent conditional and voluntary incentive schemes such as payments for ecosystem
 37564 services. All these can in principle be used to correct for policy or/and market failures and reinstate
 37565 full-cost pricing. They aim at reflecting social costs or benefits of the conservation and use of
 37566 biodiversity and ecosystem services of a public good nature (“getting the price right”). Financial
 37567 instruments, in contrast, are often extra-budgetary and can be financed from domestic sources or
 37568 foreign aid, external borrowing, debt for nature swaps, etc. Economic instruments do not necessarily
 37569 imply that commodification of environmental functions is promoted. Generally, they are meant to
 37570 change behavior of individuals (e.g., consumers and producers) and public actors (e.g., local and
 37571 regional governments).

37572 **Economic valuation** See “values”

37573 **Ecosystem** A dynamic complex of plant, animal and micro-organism communities and their non-
 37574 living environment interacting as a functional unit.

37575 **Ecosystem accounting** The process of constructing formal accounts for ecosystems

37576 **Ecosystem degradation** A persistent (long-time) reduction in the capacity to provide ecosystem
 37577 services.

37578 **Ecosystem function** The flow of energy and materials through the biotic and abiotic components of
 37579 an ecosystem. It includes many processes such as biomass production, trophic transfer through plants
 37580 and animals, nutrient cycling, water dynamics and heat transfer.

37581 **Ecosystem health** Ecosystem health is a metaphor used to describe the condition of an ecosystem,
 37582 by analogy with human health. Note that there is no universally accepted benchmark for a healthy
 37583 ecosystem. Rather, the apparent health status of an ecosystem can vary, depending upon which
 37584 metrics are employed in judging it, and which societal aspirations are driving the assessment.

- 37585 **Ecosystem management** An approach to maintaining or restoring the composition, structure,
 37586 function, and delivery of services of natural and modified ecosystems for the goal of achieving
 37587 sustainability. It is based on an adaptive, collaboratively developed vision of desired future conditions
 37588 that integrates ecological, socioeconomic, and institutional perspectives, applied within a geographic
 37589 framework, and defined primarily by natural ecological boundaries.
- 37590 **Ecosystem services** The benefits people obtain from ecosystems. In the Millennium Ecosystem
 37591 Assessment, ecosystem services can be divided into supporting, regulating, provisioning and cultural.
 37592 This classification, however, is superseded in IPBES assessments by the system used under “nature’s
 37593 contributions to people.” This is because IPBES recognises that many services fit into more than one
 37594 of the four categories. For example, food is both a provisioning service and also, emphatically, a
 37595 cultural service, in many cultures.
- 37596 **Ecotourism** Sustainable travel undertaken to access sites or regions of unique natural or ecological
 37597 quality, promoting their conservation, low visitor impact, and socio-economic involvement of local
 37598 populations.
- 37599 **Endangered species** A species at risk of extinction in the wild.
- 37600 **Endemic specie** Plants and animals that exist only in one geographic region.
- 37601 **Endemism** The ecological state of a species being unique to a defined geographic location, such as
 37602 an island, nation, country or other defined zone, or habitat type; organisms that are indigenous to a
 37603 place are not endemic to it if they are also found elsewhere.
- 37604 **Energy Security** Access to clean, reliable and affordable energy services for cooking and heating,
 37605 lighting, communications and productive uses
- 37606 **Equity** Fairness of rights, distribution, and access. Depending on context, this can refer to resources,
 37607 services, or power
- 37608 **Eutrophic** A condition of an aquatic system in which increased nutrient loading leads to progressively
 37609 increasing amounts of algal growth and biomass accumulation. When the algae die off and
 37610 decompose, the amount of dissolved oxygen in the water becomes reduced. The term is sometimes
 37611 applied more broadly than just to aquatic systems.
- 37612 **Eutrophication** Nutrient enrichment of an ecosystem, generally resulting in increased primary
 37613 production and reduced biodiversity. In lakes, eutrophication leads to seasonal algal blooms, reduced
 37614 water clarity, and, often, periodic fish mortality as a consequence of oxygen depletion.
- 37615 **Exclusive economic zone** An Exclusive Economic Zone (EEZ) is a concept adopted at the Third United
 37616 Nations Conference on the Law of the Sea (1982), whereby a coastal State assumes jurisdiction over
 37617 the exploration and exploitation of marine resources in its adjacent section of the continental shelf,
 37618 taken to be a band extending 200 miles from the shore. The Exclusive Economic Zone comprises an
 37619 area which extends either from the coast, or in federal systems from the seaward boundaries of the
 37620 constituent states (3 to 12 nautical miles, in most cases) to 200 nautical miles (370 kilometres) off the
 37621 coast. Within this area, nations claim and exercise sovereign rights and exclusive fishery management
 37622 authority over all fish and all Continental Shelf fishery resources.
- 37623 **Exploratory scenario** See "scenario".
- 37624 **Externality** A positive or negative consequence (benefits or costs) of an action that affects someone
 37625 other than the agent undertaking that action and for which the agent is neither compensated nor
 37626 penalized through the markets.

- 37627 **Extinction debt** The future extinction of species due to events in the past, owing to a time lag
 37628 between an effect such as habitat destruction or climate change, and the subsequent disappearance
 37629 of species.
- 37630 **Feedback** The modification or control of a process or system by its results or effects.
- 37631 **Food security** The World Food Summit of 1996 defined food security as existing “when all people at
 37632 all times have access to sufficient, safe, nutritious food to maintain a healthy and active life”.
- 37633 **Formal institutions** Include law and policies e.g., regulations and directives, and fiscal, agricultural
 37634 or planning policies, to name just a few examples. These are typically based on legal instruments,
 37635 treaties and customary laws. Informal institutions in turn include social norms and rules, such as those
 37636 related to collective action
- 37637 **Functional diversity** The range, actual values, relative abundance and distribution of functional trait
 37638 attributes in a given community.
- 37639 **Functional traits** Any feature of an organism, expressed in the phenotype and measurable at the
 37640 individual level, which has demonstrable links to the organism’s function. As such, a functional trait
 37641 determines the organism’s response to external abiotic or biotic factors (Response trait), and/or its
 37642 effects on ecosystem properties or benefits or detriments derived from such properties (effect trait).
 37643 In plants, functional traits include morphological, ecophysiological, biochemical and regeneration
 37644 traits. In animals, these traits include e.g. body size, litter size, age of sexual maturity, nesting habitat,
 37645 time of activity.
- 37646 **Generalist species** A species able to thrive in a wide variety of environmental conditions and that
 37647 can make use of a variety of different resources (for example, a flower-visiting insect that lives on the
 37648 floral resources provided by several to many different plants).
- 37649 **Good quality of life** Within the context of the IPBES Conceptual Framework – the achievement of a
 37650 fulfilled human life, a notion which may varies strongly across different societies and groups within
 37651 societies. It is a context-dependent state of individuals and human groups, comprising aspects such
 37652 as access to food, water, energy and livelihood security, and also health, good social relationships and
 37653 equity, security, cultural identity, and freedom of choice and action. “Living in harmony with nature”,
 37654 “living-well in balance and harmony with Mother Earth” and “human well-being” are examples of
 37655 different perspectives on a “Good quality of life”.
- 37656 **Governance** The way the rules, norms and actions in a given organization are structured, sustained,
 37657 and regulated.
- 37658 **Grassland** Type of ecosystem characterized by a more or less closed herbaceous (non-woody)
 37659 vegetation layer, sometimes with a shrub layer, but – in contrast to savannas – without, or with very
 37660 few, trees. Different types of grasslands are found under a broad range of climatic conditions.
- 37661 **Habitat** The place or type of site where an organism or population naturally occurs. Also used to
 37662 mean the environmental attributes required by a particular species or its ecological niche.
- 37663 **Habitat connectivity** The degree to which the landscape facilitates the movement of organisms
 37664 (animals, plant reproductive structures, pollen, pollinators, spores, etc.) and other environmentally
 37665 important resources (e.g., nutrients and moisture) between similar habitats. Connectivity is
 37666 hampered by fragmentation (q.v.).
- 37667 **Habitat degradation** A general term describing the set of processes by which habitat quality is
 37668 reduced. Habitat degradation may occur through natural processes (e.g. drought, heat, cold) and
 37669 through human activities (forestry, agriculture, urbanization).

- 37670 **Habitat fragmentation** A general term describing the set of processes by which habitat loss results
 37671 in the division of continuous habitats into a greater number of smaller patches of lesser total and
 37672 isolated from each other by a matrix of dissimilar habitats. Habitat fragmentation may occur through
 37673 natural processes (e.g., forest and grassland fires, flooding) and through human activities (forestry,
 37674 agriculture, urbanization).
- 37675 **Habitat service** The importance of ecosystems to provide living space for resident and migratory
 37676 species (thus maintaining the gene pool and nursery service).
- 37677 **Harmonization** The process of bringing together, and comparing, models or scenarios to make them
 37678 compatible or consistent with one another.
- 37679 **Hedgerow** A row of shrubs or trees that forms the boundary of an area such as a garden, field, farm,
 37680 road or right-of-way.
- 37681 **Hedonic pricing** An economic valuation approach that utilizes information about the implicit demand
 37682 for an environmental attribute of marketed commodities.
- 37683 **Homogenisation** When used in the ecological sense “homogenisation” means a decrease in the
 37684 extent to which communities differ in species composition.
- 37685 **Human appropriation of net primary production (HANPP)** The aggregate impact of land use on
 37686 biomass available each year in ecosystems.
- 37687 **Impact assessment** A formal, evidence-based procedure that assesses the economic, social, and
 37688 environmental effects of public policy or of any human activity.
- 37689 **Important Bird & Biodiversity Areas** A Key Biodiversity Area identified using an internationally
 37690 agreed set of criteria as being globally important for bird populations.
- 37691 **Indicators** A quantitative or qualitative factor or variable that provides a simple, measurable and
 37692 quantifiable characteristic or attribute responding in a known and communicable way to a changing
 37693 environmental condition, to a changing ecological process or function, or to a changing element of
 37694 biodiversity.
- 37695 **Indigenous and Community Conserved Areas** Natural and modified ecosystems including significant
 37696 biodiversity, ecological services and cultural values voluntarily conserved by indigenous and local
 37697 communities through customary laws or other effective means.
- 37698 **Indigenous and local knowledge systems** Indigenous and local knowledge systems are social and
 37699 ecological knowledge practices and beliefs pertaining to the relationship of living beings, including
 37700 people, with one another and with their environments. Such knowledge can provide information,
 37701 methods, theory and practice for sustainable ecosystem management.
- 37702 **Indigenous peoples and local communities** Indigenous peoples and local communities (IPLCs) are,
 37703 typically, ethnic groups who are descended from and identify with the original inhabitants of a given
 37704 region, in contrast to groups that have settled, occupied or colonized the area more recently. IPBES
 37705 does not intend to create or develop new definitions of what constitutes “indigenous peoples and
 37706 local communities.
- 37707 **Indirect driver** See “driver”.
- 37708 **Indirect use value** See “values”.
- 37709 **Institutional failure** These are often catalogued as (i) law and policy failures (e.g., perverse
 37710 subsidies), (ii) market failures (externalities in the use of public goods and services), (iii) organizational

- 37711 failure (e.g., lack of transparency and political legitimacy in decision making) and (iv) informal
37712 institutional failures (e.g., break of collective action norms due to erosion of trust.
- 37713 **Institutions** Encompasses all formal and informal interactions among stakeholders and social
37714 structures that determine how decisions are taken and implemented, how power is exercised, and
37715 how responsibilities are distributed.
- 37716 **Instrumental value** See "values".
- 37717 **Integrated assessment models** Interdisciplinary models that aim to describe the complex
37718 relationships between environmental, social, and economic drivers that determine current and future
37719 state of the ecosystem and the effects of global change, in order to derive policy-relevant insights.
37720 One of the essential characteristics of integrated assessments is the simultaneous consideration of
37721 the multiple dimensions of environmental problems.
- 37722 **Integrated pest management** Is also known as Integrated Pest Control. It is a broadly-based
37723 approach that integrates various practices for economic control of pests (q.v.). IPM aims to suppress
37724 pest populations below the economic injury level (i.e., to below the level that the costs of further
37725 control outweigh the benefits derived). It involves careful consideration of all available pest control
37726 techniques and then integration of appropriate measures to discourage development of pest
37727 populations while keeping pesticides and other interventions to economically justifiable levels with
37728 minimal risks to human health and the environment. IPM emphasizes the growth of a healthy crop
37729 with the least possible disruption to agro-ecosystems and encourages natural pest control
37730 mechanisms.
- 37731 **Integrated valuation** See "values".
- 37732 **Intrinsic value** See "values".
- 37733 **Invasive alien species** Species whose introduction and/or spread by human action outside their
37734 natural distribution threatens biological diversity, food security, and human health and well-being.
37735 "Alien" refers to the species' having been introduced outside its natural distribution ("exotic", "non-
37736 native" and "non-indigenous" are synonyms for "alien"). "Invasive" means "tending to expand into
37737 and modify ecosystems to which it has been introduced". Thus, a species may be alien without being
37738 invasive, or, in the case of a species native to a region, it may increase and become invasive, without
37739 actually being an alien species.
- 37740 **Invasive species** See "invasive alien species".
- 37741 **IPBES conceptual framework** The Platform's conceptual framework has been designed to build
37742 shared understanding across disciplines, knowledge systems and stakeholders of the interplay
37743 between biodiversity and ecosystem drivers, and of the role they play in building a good quality of
37744 life.
- 37745 **IUCN protected area category** IUCN protected area management categories classify protected areas
37746 according to their management objectives.
- 37747 **Key biodiversity areas** Sites contributing significantly to the global persistence of biodiversity. They
37748 represent the most important sites for biodiversity worldwide, and are identified nationally using
37749 globally standardised criteria and thresholds.
- 37750 **Knowledge systems** A body of propositions that are adhered to, whether formally or informally, and
37751 are routinely used to claim truth. They are organized structures and dynamic processes (a) generating
37752 and representing content, components, classes, or types of knowledge, that are (b) domain-specific
37753 or characterized by domain-relevant features as defined by the user or consumer, (c) reinforced by a

- 37754 set of logical relationships that connect the content of knowledge to its value (utility), (d) enhanced
 37755 by a set of iterative processes that enable the evolution, revision, adaptation, and advances, and (e)
 37756 subject to criteria of relevance, reliability, and quality.
- 37757 **Land degradation** Refers to the many processes that drive the decline or loss in biodiversity,
 37758 ecosystem functions or services and includes the degradation of all terrestrial ecosystems.
- 37759 **Land sharing** A situation where low-yield farming enables biodiversity to be maintained within
 37760 agricultural landscapes.
- 37761 **Land sparing** Land sparing, also called "Land separation" involves restoring or creating non-farmland
 37762 habitat in agricultural landscapes at the expense of field-level agricultural production - for example,
 37763 woodland, natural grassland, wetland, and meadow on arable land. This approach does not
 37764 necessarily imply high-yield farming of the non-restored, remaining agricultural land.
- 37765 **Land use** The human use of a specific area for a certain purpose (such as residential; agriculture;
 37766 recreation; industrial, etc.). Influenced by, but not synonymous with, land cover. Land use change
 37767 refers to a change in the use or management of land by humans, which may lead to a change in land
 37768 cover.
- 37769 **Land use change** See "land use".
- 37770 **Landscape** A human-defined area ranging in size from c. 3 km² to c. 3002 km. Landscape is spatially
 37771 heterogeneous in at least one factor of interest and often consists of a mosaic of interacting
 37772 ecosystems.
- 37773 **Landscape configuration** The distribution, size and abundances of patch types represented within a
 37774 landscape. Configuration is spatially explicit because it refers not only to the variety and abundance
 37775 of patch types, but also to their placement or location (dispersion) in the landscape.
- 37776 **Leaching** The dissolution and movement of dissolved substances by water
- 37777 **Living in harmony with nature** Within the context of the IPBES Conceptual Framework – a
 37778 perspective on good quality of life based on the interdependence that exists among human beings,
 37779 other living species and elements of nature. It implies that we should live peacefully alongside all
 37780 other organisms even though we may need to exploit other organisms to some degree.
- 37781 **Mainstreaming biodiversity** Mainstreaming, in the context of biodiversity, means integrating actions
 37782 or policies related to biodiversity into broader development processes or policies such as those aimed
 37783 at poverty reduction, or tackling climate change.
- 37784 **Mangrove** Group of trees and shrubs that live in the coastal intertidal zone. Mangrove forests only
 37785 grow at tropical and subtropical latitudes near the equator because they cannot withstand freezing
 37786 temperatures.
- 37787 **Meta-analysis** A quantitative statistical analysis of several separate but similar experiments or
 37788 studies in order to test the pooled data for statistical significance.
- 37789 **Millennium Ecosystem Assessment** The Millennium Ecosystem Assessment is a major assessment
 37790 of the human impact on the environment published in 2005.
- 37791 **Mitigation** In the context of IPBES, an intervention to reduce negative or unsustainable uses of
 37792 biodiversity and ecosystems.
- 37793 **Models** Qualitative or quantitative representations of key components of a system and of
 37794 relationships between these components. Benchmarking (of models) is the process of systematically
 37795 comparing sets of model predictions against measured data in order to evaluate model performance.

- 37796 Validation (of models) typically refers to checking model outputs for consistency with observations.
 37797 However, since models cannot be validated in the formal sense of the term (i.e. proven to be true),
 37798 some scientists prefer to use the words "benchmarking" or "evaluation". A dynamic model is a model
 37799 that describes changes through time of a specific process. A process-based model (also known as
 37800 "mechanistic model") is a model in which relationships are described in terms of explicitly stated
 37801 processes or mechanisms based on established scientific understanding, and model parameters
 37802 therefore have clear ecological interpretation, defined beforehand. Hybrid models are models that
 37803 combine correlative and process-based modelling approaches. A correlative model (also known as
 37804 "statistical model") is a model in which available empirical data are used to estimate values for
 37805 parameters that do not have predefined ecological meaning, and for which processes are implicit
 37806 rather than explicit. Integrated assessment models are interdisciplinary models that aim to describe
 37807 the complex relationships between environmental, social, and economic drivers that determine
 37808 current and future state of the ecosystem and the effects of global change, in order to derive policy-
 37809 relevant insights. One of the essential characteristics of integrated assessments is the simultaneous
 37810 consideration of the multiple dimensions of environmental problems.
- 37811 **Monitoring** The repeated observation of a system in order to detect signs of change
- 37812 **Monoculture** The agricultural practice of producing or growing a single crop, plant, or livestock
 37813 species, variety, or breed in a field or farming system at a time.
- 37814 **Mosaic landscape** A pattern of landscapes with multiple patches and corridors.
- 37815 **Mother Earth** An expression used in a number of countries and regions to refer to the planet Earth
 37816 and the entity that sustains all living things found in nature with which humans have an indivisible,
 37817 interdependent physical and spiritual relationship (see "nature").
- 37818 **Multidisciplinary expert panel** The IPBES multidisciplinary expert panel is a subsidiary body
 37819 established by the IPBES Plenary which oversees the scientific and technical functions of the Platform,
 37820 a key role being to select experts to carry out assessments.
- 37821 **Native species** Indigenous species of animals or plants that naturally occur in a given region or
 37822 ecosystem.
- 37823 **Natural capital** An economic metaphor for the limited stocks of physical and biological resources
 37824 found on earth
- 37825 **Nature** In the context of IPBES, refers to the natural world with an emphasis on its living components.
 37826 Within the context of western science, it includes categories such as biodiversity, ecosystems (both
 37827 structure and functioning), evolution, the biosphere, humankind's shared evolutionary heritage, and
 37828 biocultural diversity. Within the context of other knowledge systems, it includes categories such as
 37829 Mother Earth and systems of life, and it is often viewed as inextricably linked to humans, not as a
 37830 separate entity (see "Mother Earth").
- 37831 **Non-anthropocentric** A non-anthropocentric value is a value centered on something other than
 37832 human beings. These values can be non-instrumental (e.g. a value ascribed to the existence of specific
 37833 species for their own sake) or instrumental to non-human ends (e.g. the instrumental value a habitat
 37834 has for the existence of a specific species).
- 37835 **Non-indigenous or non-native or alien species** See "invasive alien species".
- 37836 **Ocean acidification** See "acidification".
- 37837 **Organic agriculture** Any system that emphasises the use of techniques such as crop rotation,
 37838 compost or manure application, and biological pest control in preference to synthetic inputs. Most

- 37839 certified organic farming schemes prohibit all genetically modified organisms and almost all synthetic
 37840 inputs. Its origins are in a holistic management system that avoids off-farm inputs, but some organic
 37841 agriculture now uses relatively high levels of off-farm inputs.
- 37842 **Overexploitation** Harvesting species from the wild at rates faster than natural populations can
 37843 recover. Includes overfishing, and overgrazing.
- 37844 **Participatory mapping** A key method that many indigenous communities apply in order to collect
 37845 data, information and monitoring and to use it in science- policy- society interface processes
- 37846 **Participatory scenario development (and planning)** Approaches characterised by more interactive,
 37847 and inclusive, involvement of stakeholders in the formulation and evaluation of scenarios. Aimed at
 37848 improving the transparency and relevance of decision making, by incorporating demands and
 37849 information of each stakeholder, and negotiating outcomes between stakeholders.
- 37850 **Particulate and gaseous pollutants** Air pollutants such as ozone, nitrogen oxides and ammonia
- 37851 **Particulate matter** A mixture of solid particles and liquid droplets (dust, dirt, soot, or smoke)
- 37852 **Peatlands** Wetlands which accumulate organic plant matter in situ because waterlogging prevents
 37853 aerobic decomposition and the much slower rate of the resulting anaerobic decay is exceeded by the
 37854 rate of accumulation.
- 37855 **Pelagic** Organisms that live in the water column.
- 37856 **Perennial** See "annual".
- 37857 **Permafrost** Perennially frozen ground that occurs wherever the temperature remains below 0°C for
 37858 several years.
- 37859 **Phytophilia** The positive effect of green vegetation in landscapes on human beings
- 37860 **Plankton** Aquatic organisms that drift or swim weakly. Phytoplankton are the plant forms of plankton
 37861 (e.g., diatoms), and are the dominant plants in the sea. Zooplankton are the animal forms of plankton.
- 37862 **Plenary** Within the context of IPBES – the decision-making body comprising all of the members of
 37863 IPBES.
- 37864 **Policy instrument** Set of means or mechanisms to achieve a policy goal
- 37865 **Policy mix** A combination of policy instruments which has evolved to influence the quantity and
 37866 quality of biodiversity conservation and ecosystem service provision in public and private sectors
- 37867 **Policy support tools** Approaches and techniques based on science and other knowledge systems
 37868 that can inform, assist and enhance relevant decisions, policy making and implementation at local,
 37869 national, regional and global levels to protect nature, thereby promoting nature's benefits to people
 37870 and a good quality of life.
- 37871 **Policy/policy tools** Instruments used by governance bodies at all scales to implement their policies.
 37872 Environmental policies, for example, could be implemented through tools such as legislation,
 37873 economic incentives or dis-incentives, including taxes and tax exemptions, or tradable permits and
 37874 fees.)
- 37875 **Polycentric governance** An organizational structure where multiple independent actors mutually
 37876 order their relationships with one another under a general system of rules
- 37877 **Poverty** A state of deprivation that is multidimensional in nature. Poverty is more than the lack of
 37878 income and resources to ensure a sustainable livelihood. Its manifestations include hunger and

- 37879 malnutrition, limited access to education and other basic services, social discrimination and exclusion
37880 as well as the lack of participation in decision-making
- 37881 **Precautionary principle** Pertains to risk management and states that if an action or policy has a
37882 suspected risk of causing harm to the public or to the environment, in the absence of scientific
37883 consensus that the action or policy is not harmful, the burden of proof that it is not harmful falls on
37884 those taking an action. The principle is used to justify discretionary decisions when the possibility of
37885 harm from making a certain decision (e.g., taking a particular course of action) is not, or has not been,
37886 established through extensive scientific knowledge. The principle implies that there is a social
37887 responsibility to protect the public from exposure to harm, when scientific investigation has found a
37888 plausible risk or if a potential plausible risk has been identified.
- 37889 **Process-based model** See "models".
- 37890 **Protected area** A protected area is a clearly defined geographical space, recognized, dedicated and
37891 managed, through legal or other effective means, to achieve the long-term conservation of nature
37892 with associated ecosystem services and cultural values.
- 37893 **Ramsar site(s)** A Ramsar site is a wetland site designated of international importance especially as
37894 Waterfowl Habitat under the Ramsar Convention, an intergovernmental environment treaty
37895 established in 1975 by UNESCO, coming into force in 1975. Ramsar site refers to wetland of
37896 international significance in terms of ecology, botany, zoology, limnology or hydrology. Such site
37897 meets at least one of the criteria of Identifying Wetlands of International Importance set by Ramsar
37898 Convention and is designated by appropriate national authority to be added to Ramsar list.
- 37899 **Rangeland** Natural grasslands used for livestock grazing.
- 37900 **REDD+** Reducing emissions from deforestation and forest degradation (REDD+) is a mechanism
37901 developed by Parties to the United Nations Framework Convention on Climate Change (UNFCCC). It
37902 creates a financial value for the carbon stored in forests by offering incentives for developing
37903 countries to reduce emissions from forested lands and invest in low-carbon paths to sustainable
37904 development. Developing countries would receive results-based payments for results-based actions.
37905 REDD+ goes beyond simply deforestation and forest degradation, and includes the role of
37906 conservation, sustainable management of forests and enhancement of forest carbon stocks.
- 37907 **Regime shift(s)** Substantial reorganization in system structure, functions and feedbacks that often
37908 occurs abruptly and persists over time.
- 37909 **Rehabilitation** Restoration activities that move a site towards a natural state baseline in a limited
37910 number of components (i.e. soil, water, and/or biodiversity), including natural regeneration,
37911 conservation agriculture, and emergent ecosystems.
- 37912 **Relational value** See "values".
- 37913 **Remediation** Any action taken to rehabilitate ecosystems
- 37914 **Resilience** The level of disturbance that an ecosystem or society can undergo without crossing a
37915 threshold to a situation with different structure or outputs. Resilience depends on factors such as
37916 ecological dynamics as well as the organizational and institutional capacity to understand, manage,
37917 and respond to these dynamics.
- 37918 **Resolution (spatial or temporal)** See "scale".
- 37919 **Restoration** Any intentional activities that initiates or accelerates the recovery of an ecosystem from
37920 a degraded state.

- 37921 **Richness** The number of biological entities (species, genotypes, etc.) within a given sample.
 37922 Sometimes used as synonym of species diversity.
- 37923 **Rights-based instruments and customary norms** Synergizing rights and norms for the conservation
 37924 and protection of systems of Mother Earth can foster complementarity with human wellbeing.
 37925 International and national human rights instruments whether binding or non-binding can be
 37926 creatively interpreted to fit socio-ecological systems and foster resilience. Strengthening of collective
 37927 rights, customary norms and institutions of indigenous peoples and local communities, can promote
 37928 adaptive governance including the equitable and fair management of natural resources.
- 37929 **Salinization** The process of increasing the salt content in soil is known as salinization. Salinization
 37930 can be caused by natural processes such as mineral weathering or by the gradual withdrawal of an
 37931 ocean. It can also come about through artificial processes such as irrigation.
- 37932 **Savanna** Ecosystem characterized by a continuous layer of herbaceous plants, mostly grasses, and a
 37933 discontinuous upper layer of trees that may vary in density.
- 37934 **Scale** The spatial, temporal, quantitative and analytical dimensions used to measure and study any
 37935 phenomenon. The temporal scale is comprised of two properties: 1) temporal extent – the total
 37936 length of the time period of interest for a particular study (e.g. 10 years, 50 years, or 100 years); and
 37937 2) temporal grain (or resolution) – the temporal frequency with which data are observed or projected
 37938 within this total period (e.g. at 1-year, 5-year or 10-year intervals). The spatial scale is comprised of
 37939 two properties: 1) spatial extent – the size of the total area of interest for a particular study (e.g. a
 37940 watershed, a country, the entire planet); and 2) spatial grain (or resolution) – the size of the spatial
 37941 units within this total area for which data are observed or predicted (e.g. fine-grained or coarse-
 37942 grained grid cells).
- 37943 **Scenario** Representations of possible futures for one or more components of a system, particularly
 37944 for drivers of change in nature and nature's benefits, including alternative policy or management
 37945 options. Exploratory scenarios (also known as “explorative scenarios” or “descriptive scenarios”) are
 37946 scenarios that examine a range of plausible futures, based on potential trajectories of drivers – either
 37947 indirect (e.g. socio-political, economic and technological factors) or direct (e.g. habitat conversion,
 37948 climate change). Target-seeking scenarios (also known as “goal-seeking scenarios” or “normative
 37949 scenarios”) are scenarios that start with the definition of a clear objective, or a set of objectives,
 37950 specified either in terms of achievable targets, or as an objective function to be optimized, and then
 37951 identify different pathways to achieving this outcome (e.g. through backcasting). Intervention
 37952 scenarios are scenarios that evaluate alternative policy or management options – either through
 37953 target seeking (also known as “goal seeking” or “normative scenario analysis”) or through policy
 37954 screening (also known as “ex-ante assessment”). Policy-evaluation scenarios are scenarios, including
 37955 counterfactual scenarios, used in ex-post assessments of the gap between policy objectives and
 37956 actual policy results, as part of the policy-review phase of the policy cycle. Policy-screening scenarios
 37957 are scenarios used in ex-ante assessments, to forecast the effects of alternative policy or
 37958 management options (interventions) on environmental outcomes.
- 37959 **Seascape(s)** Seascape can be defined as a spatially heterogeneous area of coastal environment (i.e.
 37960 intertidal, brackish) that can be perceived as a mosaic of patches, a spatial gradient, or some other
 37961 geometric patterning. The tropical coastal “seascape” often includes a patchwork of mangroves,
 37962 seagrass beds, and coral reefs that produces a variety of natural resources and ecosystem services.
- 37963 **Sector** A distinct part of society, or of a nation's economy.
- 37964 **Semi-natural habitat(s)** An ecosystem with most of its processes and biodiversity intact, though
 37965 altered in strength or abundance relative to the natural state

- 37966 **Socioecological system** An ecosystem, the management of this ecosystem by actors and
37967 organizations, and the rules, social norms, and conventions underlying this management.
- 37968 **Soil compaction** Defined as an increase in density and a decline of porosity in a soil that impedes
37969 root penetration and movements of water and gases.
- 37970 **Soil degradation** The diminishing capacity of the soil to provide ecosystem goods and services as
37971 desired by its stakeholders
- 37972 **Soil organic matter** Matter consisting of plant and/or animal organic materials, and the conversion
37973 products of those materials in soils.
- 37974 **Soil quality** Soil quality is a measure of the soil's ability to provide ecosystem and social services
37975 through its capacities to perform its functions under changing conditions. Soil quality reflects how
37976 well a soil performs the functions of maintaining biodiversity and productivity, partitioning water and
37977 solute flow, filtering and buffering, nutrient cycling, and providing support for plants and other
37978 structures
- 37979 **Species** An interbreeding group of organisms that is reproductively isolated from all other organisms,
37980 although there are many partial exceptions to this rule in particular taxa. Operationally, the term
37981 species is a generally agreed fundamental taxonomic unit, based on morphological or genetic
37982 similarity, that once described and accepted is associated with a unique scientific name.
- 37983 **Species composition** The array of species in a specific sample, community, or area.
- 37984 **Species distribution mode** Species distribution models relate field observations of the
37985 presence/absence of a species to environmental predictor variables, based on statistically or
37986 theoretically derived response surfaces, for prediction and inference. The predictor variables are
37987 often climatic but can include other environmental variables.
- 37988 **Species richness** The number of species within a given sample, community, or area.
- 37989 **Stakeholders** Any individuals, groups or organizations who affect, or could be affected (whether
37990 positively or negatively) by a particular issue and its associated policies, decisions and action.
- 37991 **Storylines (or scenario storylines)** Qualitative narratives which provide the descriptive framework
37992 from which quantitative exploratory scenarios can be formulated.
- 37993 **Summary for policymakers** Is a component of any report, providing a policy-relevant but not policy
37994 prescriptive summary of that report.
- 37995 **Sustainability** A characteristic or state whereby the needs of the present and local population can
37996 be met without compromising the ability of future generations or populations in other locations to
37997 meet their needs.
- 37998 **Sustainable Development Goals (SDGs)** A set of goals adopted by the United Nations in 2015 to end
37999 poverty, protect the planet, and ensure prosperity for all, as part of the 2030 Agenda for Sustainable
38000 Development.
- 38001 **Sustainable use (of biodiversity and its components)** The use of components of biological diversity
38002 in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby
38003 maintaining its potential to meet the needs and aspirations of present and future generations.
- 38004 **Synergies** See "trade-off".
- 38005 **Target-seeking scenarios** See "scenarios".

- 38006 **Taxon** A category applied to a group in a formal system of nomenclature, e.g., species, genus, family
38007 etc. (plural: taxa).
- 38008 **Telecoupling** Refers to socioeconomic and environmental interactions over distances. It involves
38009 distant exchanges of information, energy and matter (e.g., people, goods, products, capital) at
38010 multiple spatial, temporal and organizational scales.
- 38011 **Threatened species** In the IUCN Red List terminology, a threatened species is any species listed in
38012 the Red List categories, Critically Endangered, Endangered, or Vulnerable.
- 38013 **Tipping point** A set of conditions of an ecological or social system where further perturbation will
38014 cause rapid change and prevent the system from returning to its former state.
- 38015 **Trade-off** A trade-off is a situation where an improvement in the status of one aspect of the
38016 environment or of human well-being is necessarily associated with a decline in or loss of a different
38017 aspect. Trade-offs characterize most complex systems, and are important to consider when making
38018 decisions that aim to improve environmental and/or socio-economic outcomes. Trade-offs are
38019 distinct from synergies (the latter are also referred to as “win-win” scenarios): synergies arise when
38020 the enhancement of one desirable outcome leads to enhancement of another.
- 38021 **Transformation** A change in the fundamental attributes of natural and human systems that reflect
38022 strengthened, altered, or aligned paradigms, goals, or values towards promoting adaptation that
38023 supports sustainable development, including poverty reduction’
- 38024 **Transhumance** A traditional farming practice based on indigenous and local knowledge.
- 38025 **Transitional pathways** A course of actions and strategies that aim to achieve the vision. They are
38026 closely related to “policy or target-seeking scenarios”.
- 38027 **Trophic cascades** The chain of knock - on extinctions observed or predicted to occur following the
38028 loss of one or a few species that play a critical role (e.g. as a pollinator) in ecosystem functioning.
- 38029 **Trophic level** The level in the food chain in which one group of organisms serves as a source of
38030 nutrition for another group of organisms (e.g. primary producers, primary or secondary consumers,
38031 decomposers).
- 38032 **Values**
- 38033 • Value systems: Set of values according to which people, societies and organizations regulate
38034 their behaviour. Value systems can be identified in both individuals and social groups.
 - 38035 • Value (as principle): A value can be a principle or core belief underpinning rules and moral
38036 judgments. Values as principles vary from one culture to another and also between
38037 individuals and groups.
 - 38038 • Value (as preference): A value can be the preference someone has for something or for a
38039 particular state of the world. Preference involves the act of making comparisons, either
38040 explicitly or implicitly. Preference refers to the importance attributed to one entity relative
38041 to another one.
 - 38042 • Value (as importance): A value can be the importance of something for itself or for others,
38043 now or in the future, close by or at a distance. This importance can be considered in three
38044 broad classes. 1. The importance that something has subjectively, and may be based on
38045 experience. 2. The importance that something has in meeting objective needs. 3. The intrinsic
38046 value of something.
 - 38047 • Value (as measure): A value can be a measure. In the biophysical sciences, any quantified
38048 measure can be seen as a value.

- 38049 • Non-anthropocentric value: A non-anthropocentric value is a value centred on something
38050 other than human beings. These values can be non-instrumental or instrumental to non-
38051 human ends.
 - 38052 • Intrinsic value: The value inherent to nature, independent of human experience and
38053 evaluation, and therefore beyond the scope of anthropocentric valuation approaches.
 - 38054 • Anthropocentric value: Human-centred, the value that something has for human beings and
38055 human purposes.
 - 38056 • Instrumental value: The direct and indirect contribution of nature's benefits to the
38057 achievement of a good quality of life. Within the specific framework of the Total Economic
38058 Value, instrumental values can be classified into use (direct and indirect use values) on the
38059 one hand, and non-use values (option, bequest and existence values) on the other.
38060 Sometimes option values are considered as use values as well.
 - 38061 • Non-instrumental value: The value attributed to something as an end in itself, regardless of
38062 its utility for other ends.
 - 38063 • Relational value: The values that contribute to desirable relationships, such as those among
38064 people and between people and nature, as in "Living in harmony with nature".
 - 38065 • Integrated valuation: The process of collecting, synthesizing, and communicating knowledge
38066 about the ways in which people ascribe importance and meaning of NCP to humans, to
38067 facilitate deliberation and agreement for decision making and planning.
- 38068 **Vision** A desirable future (an endpoint in time) which we want to achieve. They usually consist of
38069 statements depicting the explicit desires, assumptions, beliefs and paradigms that underlie the
38070 desired future.
- 38071 **Water security** Access to safe drinking water and sanitation, both of which have become a human
38072 right.
- 38073 **Water stress** Water stress occurs in an organism when the demand for water exceeds the available
38074 amount during a certain period or when poor quality restricts its use.
- 38075 **Well-being** A perspective on a good life that comprises access to basic resources, freedom and
38076 choice, health and physical well-being, good social relationships, security, peace of mind and spiritual
38077 experience. Well-being is achieved when individuals and communities can act meaningfully to pursue
38078 their goals and can enjoy a good quality of life. The concept of human well-being is used in many
38079 western societies and its variants, together with living in harmony with nature, and living well in
38080 balance and harmony with Mother Earth. All these are different perspectives on a good quality of life.
- 38081 **Western science** Also called modern science, Western scientific knowledge or international science,
38082 and used in the context of the IPBES conceptual framework as a broad term to refer to knowledge
38083 typically generated in universities, research institutions and private firms following paradigms and
38084 methods typically associated with the 'scientific method' consolidated in Post-Renaissance Europe on
38085 the basis of wider and more ancient roots. It is typically transmitted through scientific journals and
38086 scholarly books. Some of its central tenets are observer independence, replicable findings, systematic
38087 scepticism, and transparent research methodologies with standard units and categories.
- 38088 **Wetlands** Areas that are subject to inundation or soil saturation at a frequency and duration, such
38089 that the plant communities present are dominated by species adapted to growing in saturated soil
38090 conditions, and/or that the soils of the area are chemically and physically modified due to saturation
38091 and indicate a lack of oxygen; such areas are frequently termed peatlands, marshes, swamps, sloughs,
38092 fens, bogs, wet meadows, etc.
- 38093 **Worldviews** Defined by the connections between networks of concepts and systems of knowledge,
38094 values, norms and beliefs. Individual person's worldviews are moulded by the community the person

38095 belongs to. Practices are embedded in worldviews and are intrinsically part of them (e.g. through
38096 rituals, institutional regimes, social organization, but also in environmental policies, in development
38097 choices, etc.).

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